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ICE LOAD IMPACT STUDY ON NSF R/V NATHANIAL B. PALMER

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ICE LOAD IMPACT STUDY ON NSF R/V NATHANIAL B. PALMER; INSTRUMENTATION AND MEASUREMENT SUMMARY

This report presents the results of full size ice impact testing done on the National Science Foundation's new research vessel, the NATHANIAL B. PALMER. The vessel strain gauging was planned and installed during its construction and ice impact strain recording was conducted during its initial ice trials in August 1992. This data was complemented by the instrumentation and measurement of the propulsion machinery performance, measurement of sea ice properties, and measurement of ship performance in open water. The results were compared to those of earlier similar studies done on the Swedish icebreaker ODEN and the USCGC POLAR SEA. The POLAR SEA is of similar form to the PALMER, but has twice the displacement. The ODEN is a similar displacement as the POLAR SEA, but has a different style of icebreaking bow. By comparing the results of the three vessels the authors have provided full scale justifications for future icebreaking design.

J. C. Card

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Rear Admiral, U.S. Coast Guard
Chairman, Ship Structure Committee

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16. Abstract

In August of 1992 the National Science Foundation's new research vessel, the *Nathaniel B. Palmer*, began a 3-week winter deployment to the Weddell Sea, the South Orkney Islands, and the South Shetland Islands in Antarctica. The ship operated in mid-winter ice conditions including first year and second year ice, and the deployment presented a unique opportunity to measure ice impact loads on various regions of the hull. The *Nathaniel B. Palmer* has a conventional icebreaking bow shape but about half the displacement of the *Polar* Class icebreakers and the Swedish icebreaker *Oden*, both previously instrumented. Comparing the ice loads measurements of the *Nathaniel B. Palmer* with ice load measurements on other ships in similar ice conditions provides an assessment of the effect of vessel displacement with respect to local ice loads. An instrumented bow panel has been used previously to measure local ice loads, however, the *Nathaniel B. Palmer* was instrumented with three additional panels. These panels were situated on her starboard side, on the transom, and on the bottom so that the relative magnitudes of the impact loads could be compared for similar ice conditions but different hull locations. The August 1992 deployment of the *Nathaniel B. Palmer* was the first time that this approach had been used in a full-scale ice loads measurement program. This data collection effort was complemented by the instrumentation and measurement of the propulsion machinery performance, measurement of sea ice properties, and measurement of ship performance in open water, and while icebreaking performed for other sponsors. A total of 796 ice impact events were obtained using the four instrumented hull panels.

This report subtitled "Instrumentation and Measurement Summary" describes the instrumentation and summarizes the 796 recorded impacts in terms of the total force, pressure versus contact area and the force, and pressure time-histories. Extreme value distributions are presented for pressure and force. Histograms are presented for the various sizes and shapes of the contact area. Results of this study are compared to the previous measurements on other ships and proposed load criteria. Reduced data plots for each event are given in 19 volumes subtitled "Reduced Data Plots for Each Event."

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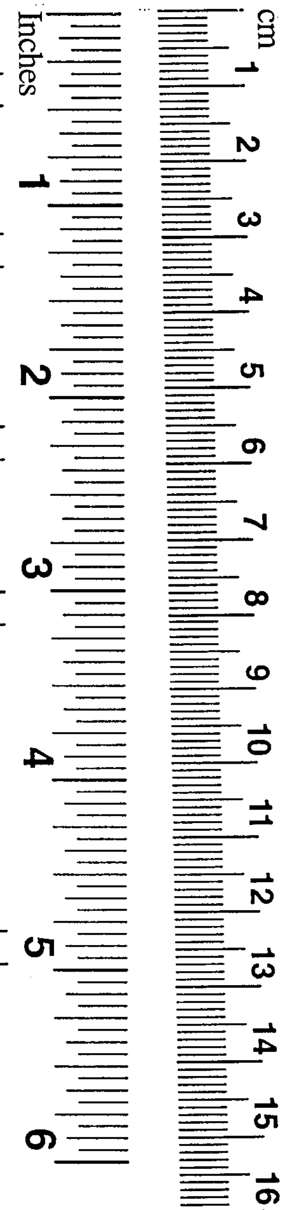
METRIC CONVERSION CARD

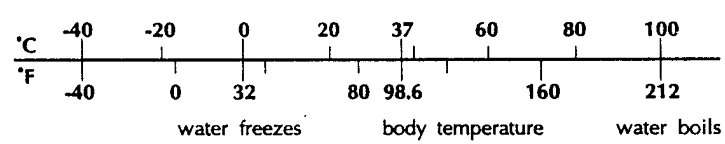
Approximate Conversions to Metric Measures

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	metric ton	t
	VOLUME			
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	16	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	degrees Fahrenheit	subtract 32, multiply by 5/9	degrees Celsius	°C



Approximate Conversions from Metric Measures

Symbol	*When You Know*	*Multiply by*	*To Find*	*Symbol*
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares ($10,000\ m^2$)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	metric ton (1,000 kg)	1.1	short tons	
	VOLUME			
mL	milliliters	0.03	fluid ounces	fl oz
mL	milliliters	0.06	cubic inches	in^3
L	liters	2.1	pints	pt
L	liters	1.06	quarts	qt
L	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	degrees Celsius	multiply by 9/5, add 32	degrees Fahrenheit	°F



CONTENTS

LIST OF FIGURES

LIST OF TABLES

PAGE

PROJECT TEAM FOR ICE LOADS MEASUREMENT

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Project Management	Rubin Sheinberg	James St. John	Michael Steele
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Deployment Project Task	Sponsoring Organization	Performing Organization
Ice Loads on Hull	Ship Structure Committee U. S. Coast Guard	Science and Tech. Corp.
Ship Performance	U. S. Coast Guard	Science and Tech. Corp.
Trafficability and Operations	National Science Foundation	Science and Tech. Corp.
Propulsion Performance and Loads	Canadian Coast Guard Northern Transport Development Centre	Fleet Tech. Ltd.
Ice and Snow Measurements	Canadian Coast Guard Northern Transport Development Centre Inst. for Marine Dynamics	Inst. for Marine Dynamics
Ice Drift	U. S. Coast Guard	Science and Tech. Corp.
Superstructure Icing	U. S. Coast Guard	Science and Tech. Corp.
Ice Navigation	National Science Foundation	Science and Tech. Corp. Antarctic Support Assoc.
Performance of Science in Ice	National Science Foundation	Antarctic Support Assoc.
Vessel Evacuation and Survivability	Canadian Coast Guard Northern Transport Development Centre	Melville Shipping Ltd.

PREFACE

In August of 1992 the National Science Foundation's new research vessel, the *Nathaniel B. Palmer*, began a 3-week winter deployment to the Weddell Sea, the South Orkney Islands, and the South Shetland Islands in Antarctica. The ship operated in mid-winter ice conditions including first year and second year ice, and the deployment presented a unique opportunity to measure ice impact loads on various regions of the hull. The *Nathaniel B. Palmer* has a conventional icebreaking bow shape but about half the displacement of the *Polar* Class icebreakers and the Swedish icebreaker *Oden*, both previously instrumented. Comparing the ice loads measurements of the *Nathaniel B. Palmer* with ice load measurements on other ships in similar ice conditions provides an assessment of the effect of vessel displacement with respect to local ice loads. An instrumented bow panel has been used previously to measure local ice loads; however, the *Nathaniel B. Palmer* was instrumented with three additional panels. These panels were situated on her starboard side, on the transom, and on the bottom so that the relative magnitudes of the impact loads could be compared for similar ice conditions but different hull locations. The August 1992 deployment of the *Nathaniel B. Palmer* was the first time that this approach had been used in a full-scale ice loads measurement program. This data collection effort was complemented by the instrumentation and measurement of the propulsion machinery performance, measurement of sea ice properties, and measurement of ship performance in open water, and while icebreaking performed for other sponsors. A total of 796 ice impact events were obtained using the four instrumented hull panels.

This project has been divided into two phases: Phase 1 consisted of the instrumentation and data collection; phase 2 involves an analysis of the data gathered and a comparison study between different ice load measurement programs on different types of icebreakers. This report documents the instrumentation process and covers the results of the data collection effort.

1. INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

The work described in this report is part of a continuing effort to improve ice load impact criteria. Previous work made extensive use of an instrumented bow panel on the *USCGC Polar Sea* to measure local area hull-ice impact loads. This was reported in a series of Ship Structure Committee reports (SSC-329, St. John et al., 1984; SSC-339, St. John et al., 1990a; and SSC-340, St. John et al., 1990b). In the fall of 1991, the Swedish icebreaker *Oden* was similarly instrumented for the measurement of local area loads on the bow during the International Arctic Ocean Expedition. This trip included a transit to the North Pole in concert with the German research icebreaker *Polarstern*. The *Oden* is about the same displacement as the *Polar Sea* but has a very different hull form. The most obvious difference is the *Oden's* wide flat bow with a low stem angle as compared to the *Polar Sea's* conventional icebreaking bow. Analysis of the *Oden* impact data set contributed to an improved understanding of the effect of hull form on icebreaking loads particularly when compared to the *Polar Sea* results (St. John and Minnick, 1993a).

There were two main objectives for the measurement of ice loads on the *Nathaniel B. Palmer*. The first was to compare the *Palmer's* bow panel results with measurements made aboard the *USCGC Polar Sea* and the *Oden*. On the *Palmer* local ice impact pressures were measured over a large panel (consisting of 42 subpanel areas in a 6 high by 7 wide array) on the bow. The comparison of the results from these measurements will help to determine the effect of displacement on ice loads since both the icebreakers *Polar Sea* and *Oden* have approximately twice the displacement of the *Nathaniel B. Palmer*. In addition, three other locations on the *Palmer* were instrumented for the measurement of ice loads; these were on the bottom, on the side near the starboard quarter, and on the transom. The objective for these measurements was to determine the relative magnitude of loads experienced at other locations on the ship as compared to ice loads at the bow where more data from other ships are available. Both the comparison of how impact loads are affected by changes in displacement and the comparison of impact loads for different parts of the icebelt are expected to lead to a greater understanding of the ice impact process, and therefore, improved ice impact load criteria.

This project was divided into two phases: The first phase consisted of instrumentation and data gathering in FY92; the second phase in FY93 involved an analysis of the data gathered and a comparison study between different ice load measurement programs on different types

of icebreakers. This report documents the instrumentation process and the results of the data collection effort of phase I, and reports on the analyses and comparison studies of phase II.

This project to measure local ice impact loads was part of a much larger program of winter ice tests on the *Nathaniel B. Palmer* involving cost sharing and joint sponsorship. In addition to the Ship Structure Committee, the U.S. Coast Guard, the Canadian Coast Guard, and the National Science Foundation sponsored parts of the program. Other aspects of the test program involved the instrumentation and measurement of the propulsion machinery performance, measurement of sea ice properties (ice thickness, strength, and other parameters), and measurement of ship performance in open water, and while icebreaking. Many of these measurements complemented the data collection effort associated with measuring ice loads.

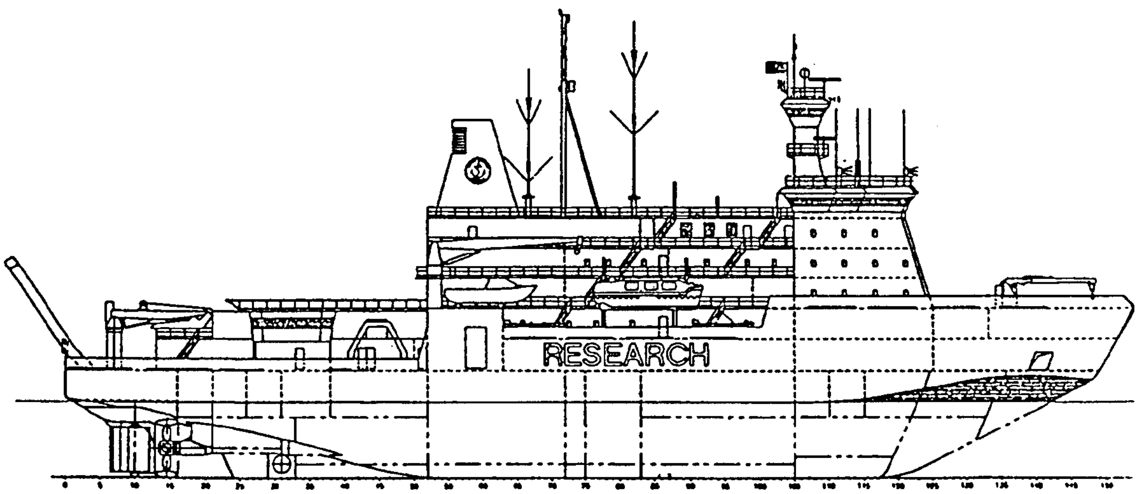
1.2 DESCRIPTION OF THE *NATHANIEL B. PALMER*

The *Nathaniel B. Palmer* is a general purpose research vessel with icebreaking capability and was designed for year-round operations in the Antarctic, for a -50°F (-45°C) air temperature, for continuous icebreaking in 36 in. (0.9 m) of level ice, and for withstanding ice impact with multiyear ice floes. The ship has a conventional wedge-shaped icebreaking bow. The *Palmer* incorporates extensive use of flat plate and conical sections in its hull, which are typical of commercial icebreaker hull forms. The ship was built and is owned by Edison Chouest Offshore, Inc., and is leased by Antarctic Support Associates for the National Science Foundation. The principal characteristics of the R/V *Nathaniel B. Palmer* are summarized in Fig. 1.

1.3 OVERVIEW OF THE INSTRUMENTATION AND MEASUREMENT PROGRAM

An opportunity existed to instrument the *Nathaniel B. Palmer* for the measurement of ice loads during her final construction period in early 1992. This meshed nicely with the scheduled deployment to the Antarctic and allowed the instrumentation to be conveniently installed in the United States prior to the *Palmer's* sailing to her permanent port of Punta Arenas, Chile. It also allowed easier access to the regions needed for instrumentation as this was done prior to the final outfitting.

Before the actual instrumentation could begin, finite element models were developed as required to determine the optimum location for the strain gages used to measure impact pressures on the hull of the vessel and to determine the response matrix at the gages due to



PRINCIPAL CHARACTERISTICS

Length Overall	308.50 feet
Length at Waterline	279.75 feet
Beam at Design Waterline	60.00 feet
Draft at Design Waterline	21.75 feet
Depth	30.00 feet
Displacement	6,500 LT
Shaft Horsepower	12,720 SHP
Accommodations	37 scientists 26 crew
Helicopters	Ability to carry 2
Endurance	75 days

Figure 1. U.S. Antarctic Research Vessel *Nathaniel B. Palmer.*

unit pressures over the measurement areas. These analyses took into account the actual structure of the ship at the bow panel, and at the selected bottom, side, and transom frames. The strain gage locations were spaced at regular intervals along the length of the frames.

In January of 1992 the hull of the *Palmer* was instrumented with 59 strain gage pairs on the bow framing and at the other three locations. The necessary cabling was run throughout the length of the ship to dry stores where it was connected to instrumentation amplifiers, analog-to-digital converters, and a computer that controlled the whole data measurement system. The system was able to detect impact loads on any of the instrumented hull panels above a preset threshold. The triggering initiated the recording of all channels on all of the panels for 5 sec. Each recorded event would include a 1 sec segment of data prior to the trigger event so that the initial portions of the impact were also captured. The entire instrumentation system was deactivated and sealed for safekeeping during the *Palmer's* transit to her base in Punta Arenas and her initial deployment into Antarctic waters.

About one week prior to the August deployment, the test team arrived in Punta Arenas to reactivate the instrumentation system and make any adjustments that might be required. Much to their surprise and good fortune, all installed strain gages were in good working order including those that were in a water ballast tank that had been filled several times. During the deployment, ice impact loads using the instrumentation system were obtained on all four hull panels. The trigger threshold was set to a higher level on the bow panel since higher loads were expected at this location. Throughout the data acquisition process ice conditions were recorded on a regular basis using bridge observers and using direct measurement of the ice when possible. Once sufficient data was obtained, a first pass at the data reduction was conducted onboard. Several of the significant events were converted from strain measurements to loads in engineering units so the magnitude and distribution of pressures and total load could be computed. A total of 796 ice impact events were obtained using the four instrumented hull panels.

2. DESCRIPTION OF THE INSTRUMENTATION

2.1 LOCATIONS ON THE SHIP AND RATIONALE

Four regions on the underwater hull of the icebreaking research vessel *Nathaniel B. Palmer* were instrumented in January of 1992 with strain gages so ice impact events could be recorded during the vessel's upcoming deployment into the Weddell Sea. Figure 2 indicates the locations of these hull panels on an outboard profile view of the *Nathaniel B. Palmer.* Three of these instrumented regions were located in the icebelt on the starboard side at the bow, along the side, and at the transom. The fourth region was on the bottom in the transducer space.

The area selected for the bow panel is similar in overall size and location to the bow panel on the *Polar Sea.* The hull angles are also roughly the same between the two vessels at their panels. The instrumented location covers portions of two compartments with the upper half extending into dry stores and the lower half in a water ballast tank. Like the *Polar Sea* bow panel, a deck with supporting structure runs through the middle of the *Palmer's* bow panel. The effect of the deck and brackets on the response of the hull panel was accounted for in the finite element modeling. Seven cant frames were instrumented on the starboard side (CF 118 through CF 124) with six gage pairs on each frame. The gages measured compression in the web of the frame perpendicular to the shell and the strain was associated with the pressure over an area of shell plating centered under the gage (gage spacing by frame spacing) termed a subpanel area. In Fig. 3 are shown the structural arrangements taken from the ship's plans for CF 121 (the other cant frames, CF 118 through CF 124, are similar).

The bottom panel was located in the transducer space along the centerline in the forwardmost portion of the flat portions of the bottom of the ship. The transducer space was selected for accessibility. Three transverse floors were instrumented with two gage pairs each, in a similar manner to the bow. The floors were used instead of the longitudinal girders in this location because of their greater sensitivity to the expected hull loads as determined from the finite element analysis. The dimensions for one of the floors are shown in Fig. 4.

The side panel was located in the scientific container hold on the starboard side or quarter of the ship. Two frames (frames 39 and 40) were instrumented with three gage pairs each starting from the deck and proceeding upward to the waterline, in a similar manner to the bow. The side frames are similar to the bow frames, as shown in Fig. 5.

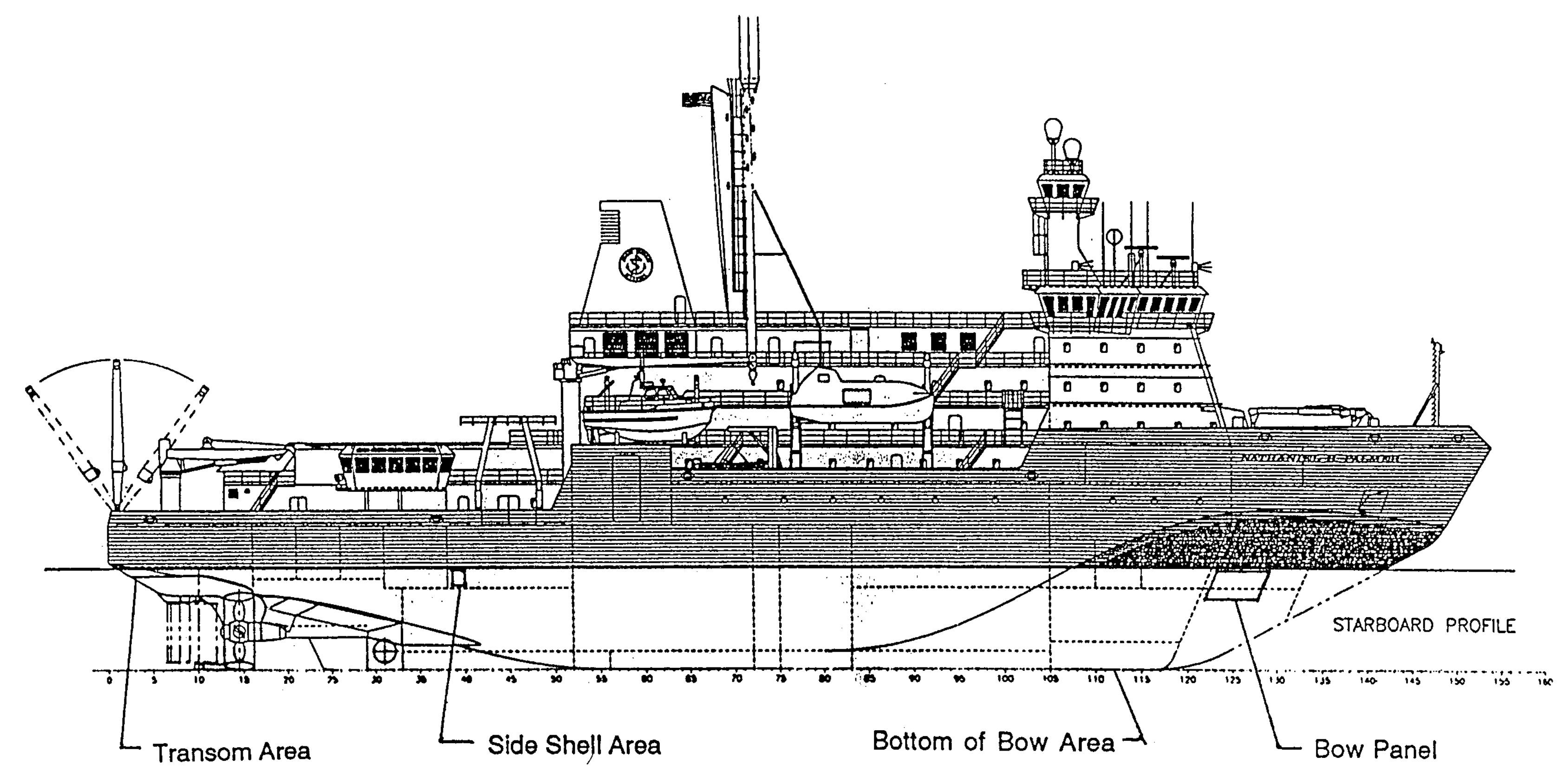


Figure 2. Locations for the measurement of local ice impact loads.

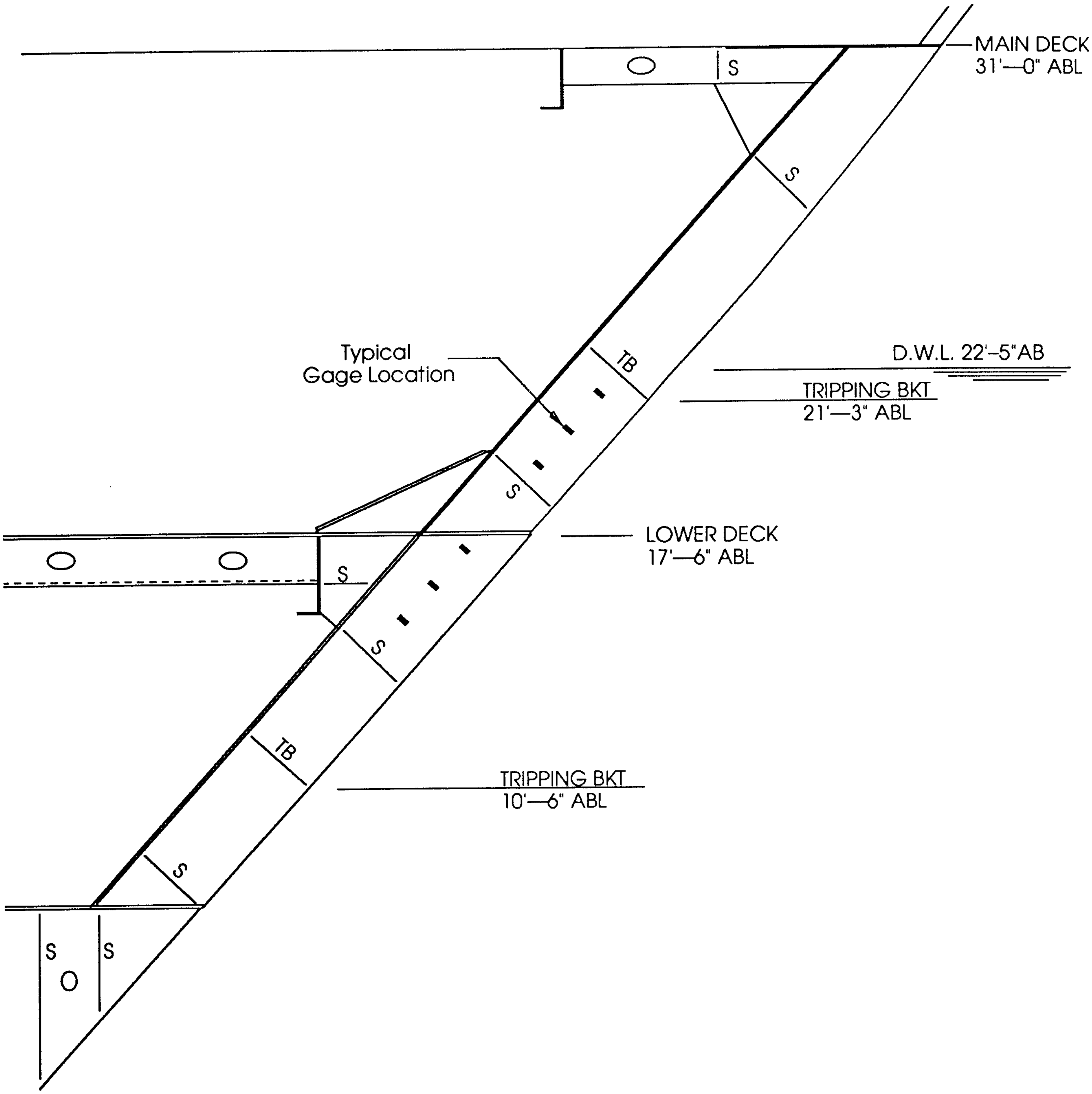
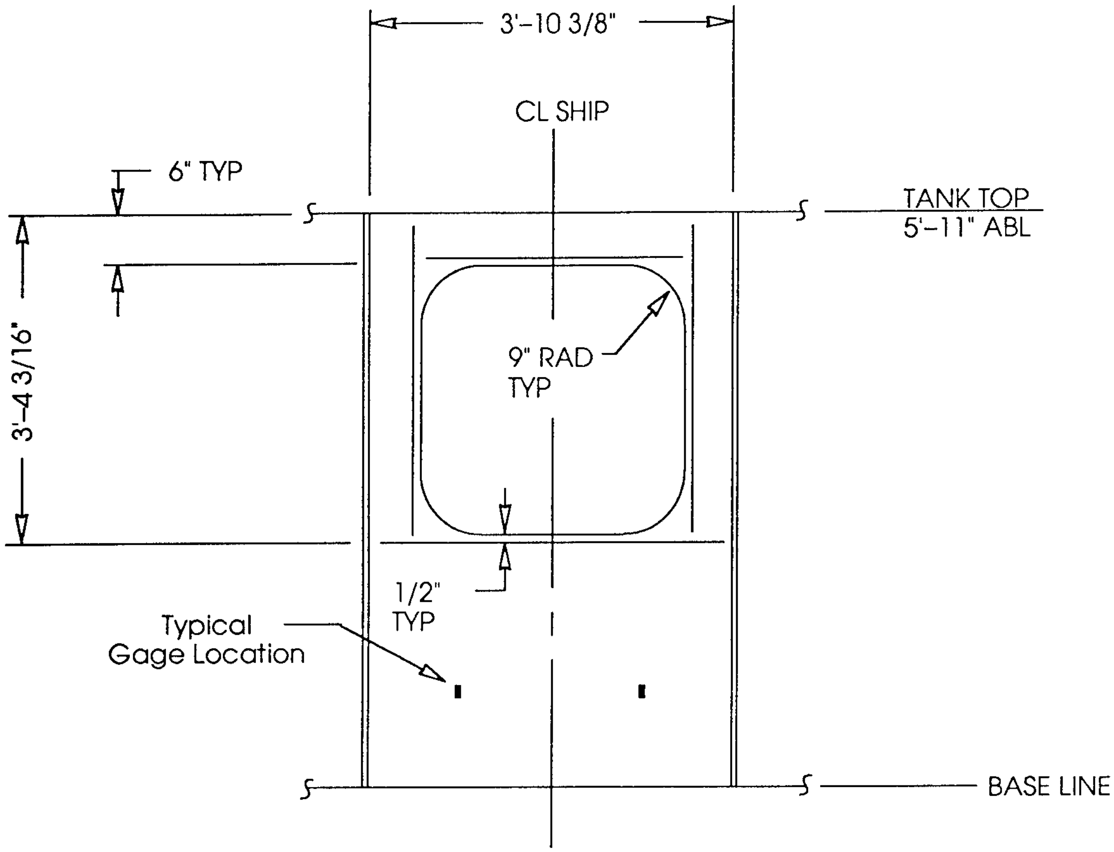


Figure 3. Cant frame 121 drawn looking forward on true cant section.



SCALE: 1/2" = 1'-0"

Figure 4. Floors at cant frames 107 through 113 (frame 107 shown looking forward).

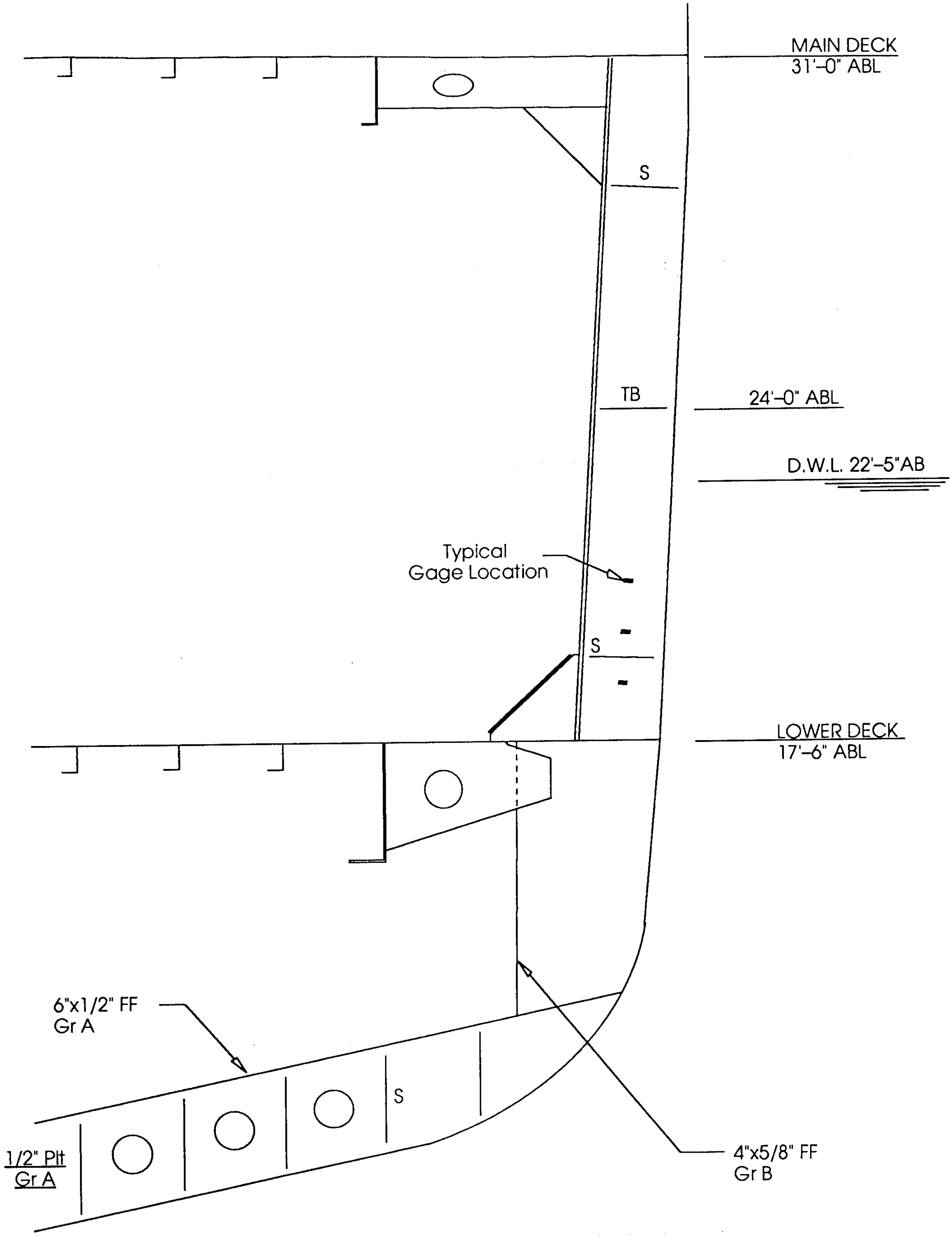


Figure 5. Transverse frame 39.

Only one longitudinal frame was instrumented in the transom area. The frame was located at the waterline 4 ft off centerline to starboard and was instrumented with five gage pairs, in a similar manner to the bow. The location was selected because it was one of the only stern frames accessible. The structural arrangement for this longitudinal girder is shown in Fig. 6.

2.2 EXPECTED LOADS

Prior to the trip, the expected loads on the sensors were computed to size the range and sensitivity of the data acquisition system properly. Limiting pressures on the sensors were determined by scaling the limiting pressures measured on the *Polar Sea* in multiyear ice. The *Polar Sea* peak pressure on one subpanel (an area of 235 in^2 or 0.15 m^2) was 1640 psi (11.3 MPa), and the peak load on the panel was just over 500 LT (5.0 MN) (St. John et al., 1990b). Since the bow panels of the two ships were about the same size, but the *Palmer* was approximately half the displacement, the highest total loads on the bow panel were expected to be in the range of 250 LT (2.5 MN).

This value, however, is not important in sizing the data acquisition system. What is important is the expected peak load on each subpanel area since this value will determine the peak expected strain. The *Palmer* has a larger frame spacing than the *Polar Sea* so the subpanel areas are larger. The area associated with each sensor is 333 in^2 (0.21 m^2) for the *Palmer*. It was seen from the *Polar Sea* and other data that the peak pressure over a given area decreases with increasing area approximately to the -0.2 power. Therefore, a smaller peak pressure should be expected for the *Palmer*, given the same ice conditions. In Table 1 is shown the calculation of peak pressure based on the 1640 psi (11.3 MPa) measurement aboard *Polar Sea* in multiyear ice.

Table 1. Expected Pressures and Strains for the *Nathaniel B. Palmer's* Hull Loads Measurement System

Hull Panel	Gage Spacing (in.)	Frame Spacing (in.)	Sensor Area (in^2)	Expected Peak Pressure (psi)	Expected Peak Strain ($\mu\varepsilon$)
Bow	16	20.8	333	1530	646
Bottom	23.6	24	566	1370	411
Side	12	24	288	1574	683
Transom	15	24	360	1500	721

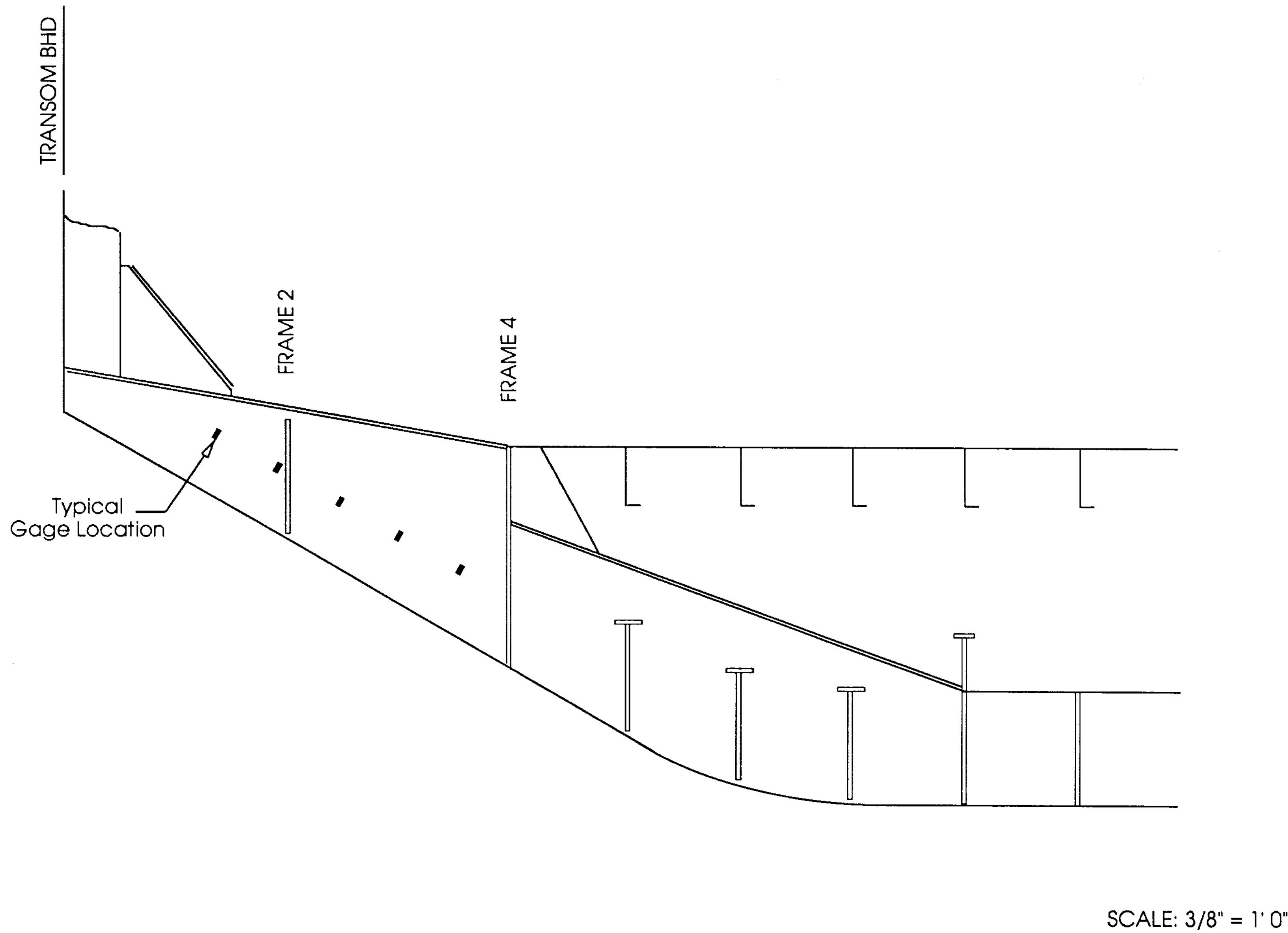


Figure 6. Longitudinal girder 4 ft off centerline (port and starboard).

The expected peak strain was computed from the expected peak pressure by scaling the largest strain response to a 1000 psi (6.9 MPa) pressure from the finite element models. This value of maximum strain was determined to be 1000 με, and the gains on all channels were set accordingly. The maximum strain will give some margin above the peak measured strain while keeping the resolution high and the gains consistent across the channels.

Multiyear pressures were used to compute the expected strains because they are believed to be the highest local pressures the structure can see. If the ship encountered multiyear ice, the test team wanted to be able to record the loads. The team also computed the expected pressures for first year ice based on the same procedure. The *Polar Sea* had experienced a maximum first year ice pressure of 745 psi (5.1 MPa) in the North Bering Sea in 1983 (St. John et al., 1990b). Based on this pressure the *Palmer* should see peak pressures of approximately 700 psi (4.8 MPa) on the bow panel in winter first year ice.

2.3 DESCRIPTION OF THE INSTRUMENTATION SYSTEM

The design of the hull loads instrumentation system was similar to instrumentation systems used in prior hull loads measurement projects (St. John et al., 1984, St. John et al., 1990a, and St. John et al., 1990b). Several considerations about the data requirements influence the design of the system. First of all, a large number of channels were required to maximize the total panel area given that one channel of data would be required for each subpanel area. Since digital recording was employed, data records had to be sampled at high frequency, and with many channels and potentially long duration impact events, real-time data storage was required. Furthermore, since the panels would likely encounter many impacts throughout the deployment, one could potentially be overwhelmed with data, thus making data reduction an exceedingly complicated task. It was apparent that the data recorded should ideally be limited to only the data of interest; that is, the data above some predetermined pressure, thereby minimizing the amount of data that must be reduced. It was also of interest to provide onboard data reduction of strains to pressures to give the engineers acquiring the data a feel for the level of loading and the validity of the data.

A microprocessor-driven digital system was selected with the system constantly monitoring and digitizing all channels from the four hull panels at a frequency of 31 Hz. A sampling frequency of 31 Hz was selected as the practical minimum frequency given the rise times noted in previous measurement programs. Each hull panel had one or more carefully selected trigger channels, so that if the strain level on any one trigger channel exceeded a threshold strain, all 59 channels were recorded to a storage device. The recording duration

was 5 sec, and 1 sec of data was constantly saved in memory in the data acquisition microprocessor. Consequently, when the strain on one trigger channel exceeded the threshold, the strains from 1 sec before the trigger time to 4 sec after the trigger time were written to the computer disk, thus capturing the initial rise in strain to the threshold strain on all channels.

An overview of the system for the instrumented bow panel is presented in Fig. 7. Considering just the bow panel, six rows of weldable, single-axis strain gage pairs were installed on each of seven frames (84 gages in total). Half of the gages were in dry stores above the lower deck, and half in the water ballast tank below the lower deck. The computer and signal conditioning rack was established in dry stores within reach of all the gage lead wires. Each gage pair was wired directly to an instrumentation amplifier mounted in the rack. At the other instrumented locations of the ship, signal amplifiers were mounted in the lowest noise region possible in the vicinity of the strain-gaged frames. As before, each gage pair was wired directly to an amplifier, but in these cases, large multi-conductor cables were run through the ship to the instrumentation rack in dry stores. A set of terminal strips mounted on the back of the instrument rack were used to organize all of the output wires from the signal amplifiers, which in turn provided the 59 channels of data input to the analog-to-digital converters. The data acquisition computer performed all collection of data, including the saving of 1 sec of data in memory and testing the trigger channels for threshold exceedance. In Table 2 a channel map is presented listing all 59 data channels, their location on the hull, and their assigned channel number.

The strain gages used in the instrumentation were mounted on the frame webs at carefully selected distances back from the shell plating and at known separation distances along the web. Each strain gage, or pair of strain gages fitted to opposite sides of a frame web, measured the strain time-history for that particular location. Since all the gages within a hull region were sampled simultaneously during ice impact events, a map of the strain variation across the instrumented portion of the hull could be obtained. When converted using the specifically developed data reduction matrix, the map of strain time-histories becomes a map of the ice pressure distribution acting on the hull of the ship. All of the gages were waterproofed for their protection. In fact, none of the gages had to be replaced even though 6 months had elapsed between the time of their installation and the time of the deployment, and the fact that the water ballast tank was filled on several occasions.

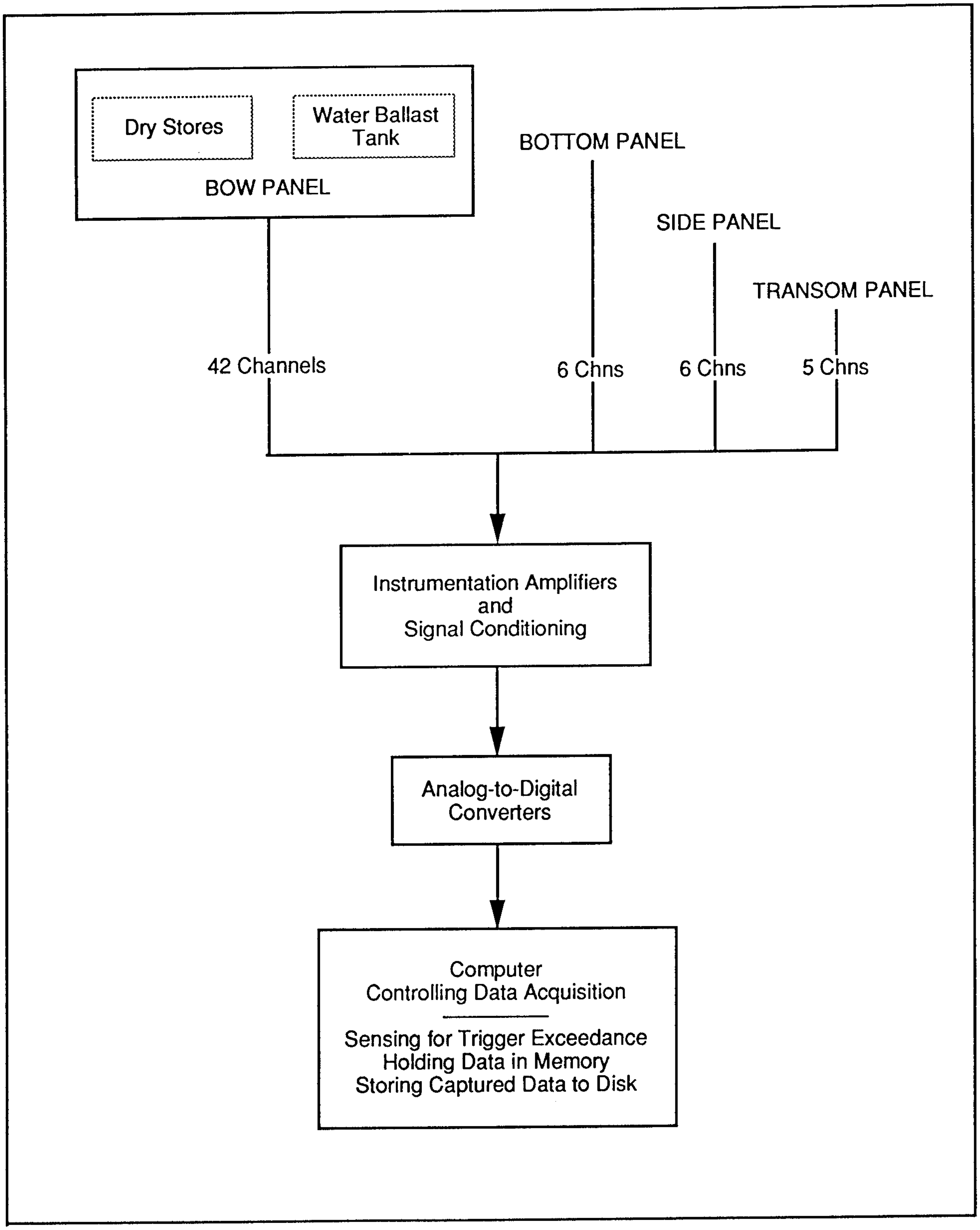


Figure 7. Schematic of the data collection system.

Table 2. *Nathaniel B. Palmer* Ice Load Sensor Channel Map

Gage Channel No.	Hull Panel	Compartment of Gage Location	Frame Identification	Frame No.	Row from Top or Left
1	Bow	Dry Stores	CF 124	1	1
2	Bow	Dry Stores	CF 124	1	2
3	Bow	Dry Stores	CF 124	1	3
4	Bow	No. 2 WB Tank	CF 124	1	4
5	Bow	No. 2 WB Tank	CF 124	1	5
6	Bow	No. 2 WB Tank	CF 124	1	6
7	Bow	Dry Stores	CF 123	2	1
8	Bow	Dry Stores	CF 123	2	2
9	Bow	Dry Stores	CF 123	2	3
10	Bow	No. 2 WB Tank	CF 123	2	4
11	Bow	No. 2 WB Tank	CF 123	2	5
12	Bow	No. 2 WB Tank	CF 123	2	6
13	Bow	Dry Stores	CF 122	3	1
14	Bow	Dry Stores	CF 122	3	2
15	Bow	Dry Stores	CF 122	3	3
16	Bow	No. 2 WB Tank	CF 122	3	4
17	Bow	No. 2 WB Tank	CF 122	3	5
18	Bow	No. 2 WB Tank	CF 122	3	6
19	Bow	Dry Stores	CF 121	4	1
20	Bow	Dry Stores	CF 121	4	2
21	Bow	Dry Stores	CF 121	4	3
22	Bow	No. 2 WB Tank	CF 121	4	4
23	Bow	No. 2 WB Tank	CF 121	4	5
24	Bow	No. 2 WB Tank	CF 121	4	6
25	Bow	Dry Stores	CF 120	5	1
26	Bow	Dry Stores	CF 120	5	2
27	Bow	Dry Stores	CF 120	5	3
28	Bow	No. 2 WB Tank	CF 120	5	4
29	Bow	No. 2 WB Tank	CF 120	5	5
30	Bow	No. 2 WB Tank	CF 120	5	6
31	Bow	Dry Stores	CF 119	6	1
32	Bow	Dry Stores	CF 119	6	2
33	Bow	Dry Stores	CF 119	6	3
34	Bow	No. 2 WB Tank	CF 119	6	4
35	Bow	No. 2 WB Tank	CF 119	6	5
36	Bow	No. 2 WB Tank	CF 119	6	6
37	Bow	Dry Stores	CF 118	7	1
38	Bow	Dry Stores	CF 118	7	2
39	Bow	Dry Stores	CF 118	7	3
40	Bow	No. 2 WB Tank	CF 118	7	4
41	Bow	No. 2 WB Tank	CF 118	7	5
42	Bow	No. 2 WB Tank	CF 118	7	6
43	Bottom	Transducer Space	CF 110-Fwd-Port	1	1
44	Bottom	Transducer Space	CF 110-Fwd-Stbd	1	2
45	Bottom	Transducer Space	CF 109-Mid-Port	2	1
46	Bottom	Transducer Space	CF 109-Mid-Stbd	2	2
47	Bottom	Transducer Space	CF 108-Aft-Port	3	1
48	Bottom	Transducer Space	CF 108-Aft-Stbd	3	2
49	Side	Scientific Container Hold	Frame 40	1	1
50	Side	Scientific Container Hold	Frame 40	1	2
51	Side	Scientific Container Hold	Frame 40	1	3
52	Side	Scientific Container Hold	Frame 39	2	1
53	Side	Scientific Container Hold	Frame 39	2	2
54	Side	Scientific Container Hold	Frame 39	2	3
55	Transom	Steering Flat	Girder 4' to Stbd	1	1
56	Transom	Steering Flat	Girder 4' to Stbd	1	2
57	Transom	Steering Flat	Girder 4' to Stbd	1	3
58	Transom	Steering Flat	Girder 4' to Stbd	1	4
59	Transom	Steering Flat	Girder 4' to Stbd	1	5

A table of the calibration data for each channel is enclosed in Appendix A. Shunt calibrations were performed as follows: each strain gage bridge (pair of gages on the frame with its completion resistors in the amplifier) was unbalanced both positively and negatively with a 98,000-Ω resistor that simulated a strain of 875 $\mu\varepsilon$. The positive and negative voltages, as well as the voltage with a balanced bridge, were noted. In the table is shown a comparison of the actual versus simulated voltage and strain outputs. The actual voltages were used to compute the actual calibration factor for each channel, as shown in the rightmost column of the table. Measured output voltages on the amplifiers could then be related to actual strain in the structure.

3. DESCRIPTION OF FINITE ELEMENT MODELS

3.1 OVERVIEW OF THE MODELING APPROACH

Portions of the hull structure at each of the four hull regions of the *Nathaniel B. Palmer* were investigated using a finite element program in order to gain a better understanding of the interaction of the hull structure to ice impact loading, and to develop the necessary data reduction matrices. These models were used to determine the best location for the strain gages both in terms of setback from the shell plating and spacing along the frame. A rectangular section of the hull plating centered on the gage location equal to the frame spacing in one direction and the gage spacing in the other direction defines a subpanel within the instrumented hull panel. Ideally, each gage would sense pressure only over its respective subpanel, however, pressures on adjacent subpanels do influence the gage pair reading, therefore, a data reduction influence matrix was necessary in order to interpret the results correctly as pressures.

The COSMOS/M finite element software package was used for this analysis. Early developmental models used a simple I-beam geometry with a point load centered on a simply-supported beam to validate the response of the beam with the classical solution. These models used the same web and flange dimensions as the frames used on the *Nathaniel B. Palmer* and were made up of thin plate finite elements. The plate elements were adjusted in size until sufficiently accurate deflection responses were achieved, thus establishing the basic size for plate elements in the more detailed framing models.

All of the initial finite element models for the four hull regions consisted of one frame of sufficient length to span the instrumented section of the frame terminating at major brackets or other supporting structure. Attached to the frame were the shell plating to the two neighboring frames, connecting decks, if any, and all stiffeners, brackets, tripping brackets, and attached deck beams, as appropriate. Once the actual locations for the strain gages were selected, two nodes were placed at what would be the ends of an actual strain gage 1/2 in. (12.7 mm) apart. Thus, for a given loading condition, the displacements at the two nodes could be obtained. The normalized difference between the displacements gave the strain in the web at that point. Each gage location was assumed to be loaded by a uniform pressure over a rectangular "subpanel area" that extended from midgage to midgage along the frame and midspan to midspan perpendicular to the frames. The basic loading condition consisted of a uniform 1000 psi (6.9 MPa) pressure load distributed across the subpanel area and

centered on the shell plating over a gage location. Displacements were obtained at all gage locations, and reaction forces were obtained at the nodes along the edges of the shell plating.

Initial results for all gage locations indicated that the 1000-psi uniform patch load results in strains of around 250 to 400 $\mu\varepsilon$ at the gage located directly beneath the load in the web. In locations where a large tripping bracket connects two frames together or near decks with their supporting structure, a large part of the frame load could be transferred to the adjoining frame through shear loading. This transfer of loading through shear was primarily true of the bow and side regions. In general, the strain at the gage on an adjoining frame is about 12 percent of the strain experienced by the gage under the uniform patch load. A more detailed two-frame finite element model was developed for the bow and side areas in order to determine with greater accuracy the sensitivity of the response of a gage on the unloaded second frame due to a uniform patch load over an adjacent gage on the first frame. The following sections describe the initial finite element work leading to the selection of the gage positions, the development of more detailed models used to determine the influence matrix for each instrumented panel, and the construction of the influence matrices for data reduction.

3.2 SELECTION OF GAGE SPACING

Prior to the installation of the strain gages, a series of finite element models were developed to investigate strain sensitivity throughout the frame web due to a point load acting on the shell plating. Two primary considerations led to the selection of the most desirable locations for the placement of the strain gages. The first was that the gage setback distance from the shell plating should be sufficient for the gage to register the strain due to the expected impact loads. That is to say, the amount of strain in the frame web decreases with distance from the plating, so that the gages are more responsive when placed nearer to the shell plating. The second consideration involves the gage spacing, or the distance between neighboring gages along the frame. For a given setback distance, the strain response decreases as the load moves further away from the gage position along the web. Ideally, when the load is directly over one gage, the strain at the neighboring gage should be zero. Also when the load is acting on the shell plating directly between the two gages, the response at each gage should be about 50 percent of the directly loaded response. These are two competing requirements since gages that are placed too close to the shell plating can have a "dead zone" between the two neighboring gages unless the gage spacing is also decreased.

The approach used with the finite element models was to generate a map of displacements throughout the depth and length of the frame web due to a concentrated load

for each of the four hull areas to be instrumented. These displacements were converted into strains and plotted in terms of distance from the plating into the web and distance from the load along the frame. Table 3 summarizes the results for each instrumented panel. Most of the plating used in the construction of the *Palmer* is metric, however all the structural dimensions are in English units. The unusual dimension for frame spacing on the bow comes from the angle of the cant frames.

Table 3. Position of Strain Gages

Hull Panel	Plate Thickness	Frame Spacing (in.)	Gage Spacing (in.)	Setback Distance (in.) *
Bow	40 mm <> 1.575 in.	20.8	16	13.5
Bottom	40 mm <> 1.575 in.	24	23.6	9.0
Side	32 mm <> 1.260 in.	24	12	17.0
Transom	32 mm <> 1.260 in.	24	15	12.5

* Measured from mid-thickness of the shell plating.

Other considerations for the placement of the strain gages included the desire to maximize the total panel area covered by the array of gages and local structural arrangements affecting the beam geometry.

3.3 BOW MODEL

Initially, three finite element models were developed for cant frames 118, 121, and 124. These are the aftermost and longest instrumented frame, the middle frame, and the forwardmost and shortest frame, respectively. The structural arrangements taken from the ship's plans for CF 121 and the bow frames in general were given in Fig. 3. In Fig. 8 is shown the finite element mesh for a single frame model of CF 121. All three framing models extended up to the upper bracket connected to the deck above (this distance was the same for the three frames), extended along the deck to the centerline of the ship, and extended down to the bracket structure below the deck. Results from these runs indicated that there was virtually no difference between the different frames due to the lengths of the lower part of the frame or deck structure. In addition, it was concluded that the deck running through the middle of the panel and the longitudinal "tripping brackets" connecting all of the bow frames together were effective in transferring part of the load onto adjoining frames. Furthermore, it was necessary

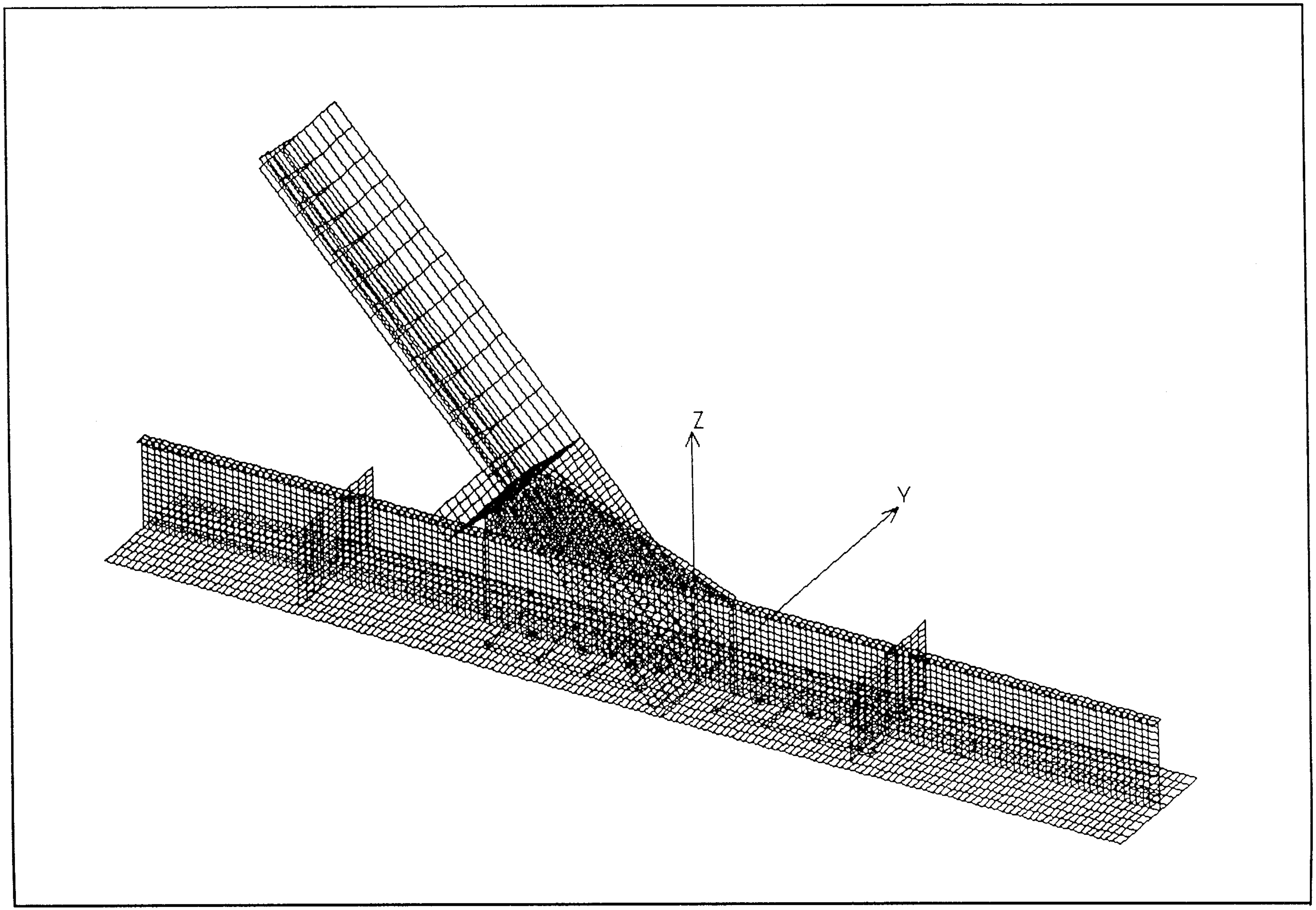


Figure 8. Finite element mesh of CF 121 (single frame model).

to include the hole that exists in each tripping bracket section between frames in a refined model. Similar conclusions concerning the load transference between frames were reached for the side panel based on its single frame finite element model.

More complex bow and side panel models were developed, which covered two frames and three frame bays each and included the holes in the tripping brackets. These models showed that the amount of strain registered at the neighboring gage on an adjoining frame is close to 12 percent of the strain experienced by the gage under the uniform patch load. The bow model finite element output results giving the strain at each of the six gage locations along one loaded frame and the six gage locations along the unloaded adjoining frame were obtained for the six loading conditions along the loaded frame. Shown in Fig. 9 is a greatly distorted resultant displacement view of the two-frame finite element model for CF 121 with a 1000-psi uniform load applied over the second gage location. The frame in the foreground is the loaded frame, and the darker shading indicates greater displacement. The amount of strain reduction computed between the loaded gage location on one frame and the gage locations on the adjacent frame were used to determine the amount of strain at every gage location for each of the subsequent frames. Thus, the influence between a loaded gage and each of the other gage locations was established. Appendix B gives the influence matrices for all four hull panels based on the finite element modeling results. These matrices relate the strain at a gage location to the pressure applied on a single subpanel of shell plating or a distribution of pressures acting on a collection of subpanels.

3.4 BOTTOM MODEL

Three identical, adjacent, transverse floors in the transducer space were instrumented with gages at two locations on each floor. In Fig. 4 the structural arrangement was shown for one of the floors and in Fig. 10 the finite element mesh model is shown along with one of the loading conditions. Because of the two gage locations only two loading conditions were used, but results from the finite element model indicated that there was almost no difference between the two load cases because of the symmetry of the problem. Reaction forces were also obtained along the sides of the model's shell plating to determine the amount of the load transferred onto the adjoining structure. The influence matrix for the bottom panel is given in Appendix B.

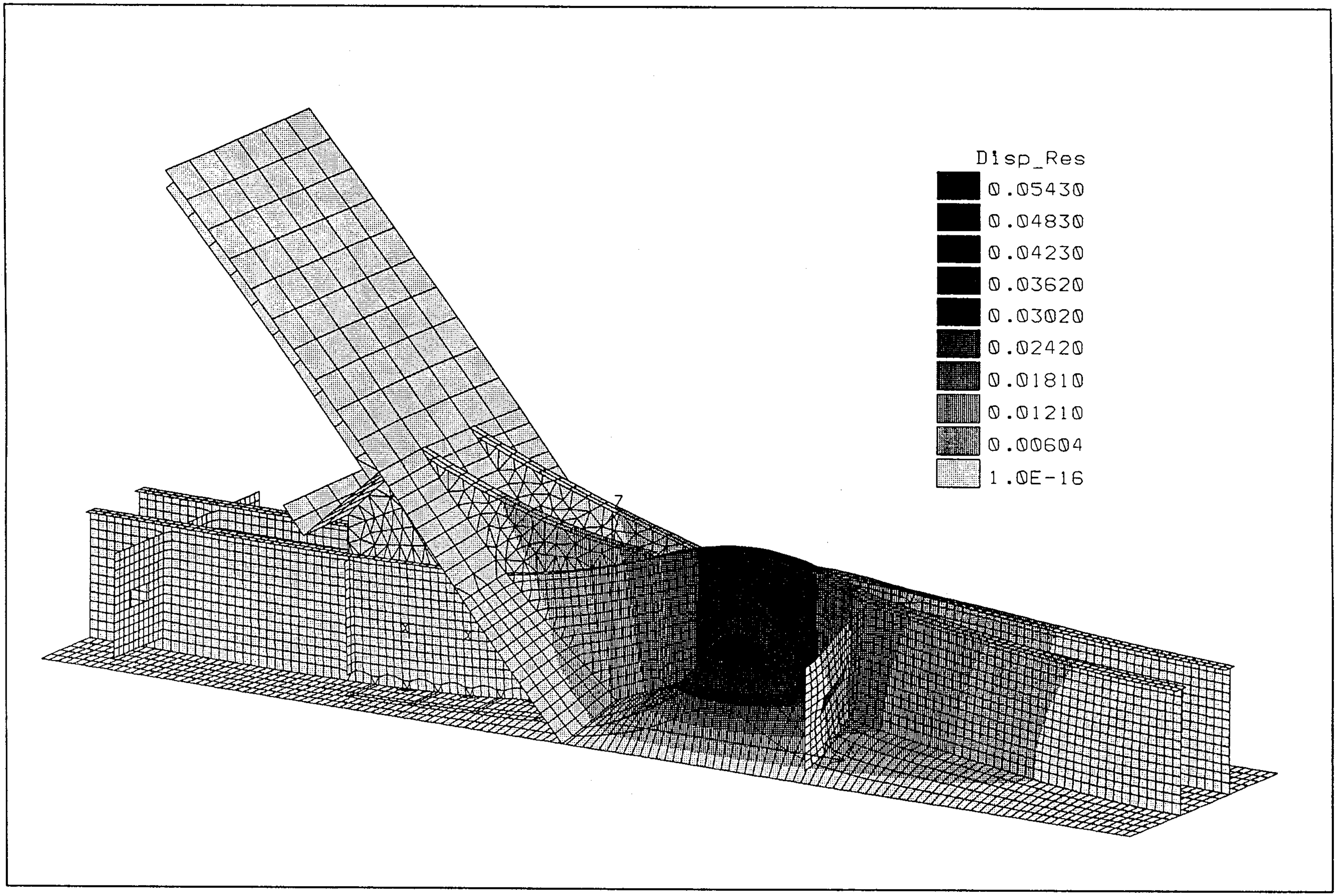


Figure 9. Resultant displacement for uniform loading at gage location 2 on CF 121.

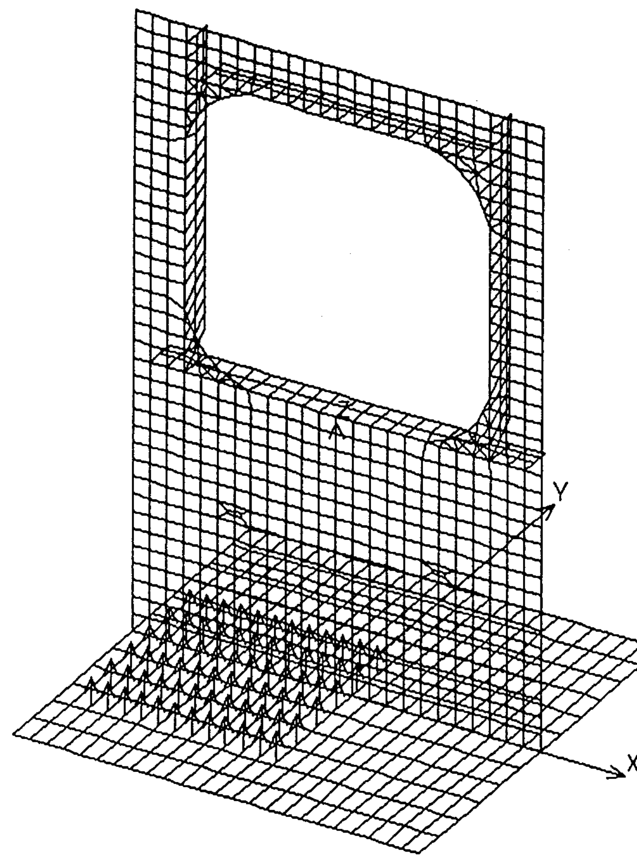


Figure 10. Finite element mesh of floor at CF 107.

3.5 SIDE MODEL

The side frames are similar to the bow frames (Fig. 5). In this case, the strain gages were placed from the lower deck up toward the waterline, unlike the bow panel, which has the deck running through the middle. The initial side region finite element model covered transverse frame 39 from the lower deck to the bracket of the deck above, adjoining shell plating, brackets, stiffeners, and the tripping bracket connecting frame 39 to frame 40. This is shown in Fig. 11. The results of this model indicated that frame 40 should be included in the model and that a hole should be incorporated in the tripping bracket, as was done for the bow region. These two frames were instrumented with three gages per frame, and finite element output results giving the strain at each of the six gage locations were obtained for the three loading conditions along frame 39. The additional three loading conditions were not needed along frame 40 because of the symmetry of the problem. The influence matrix for the side panel is given in Appendix B.

3.6 TRANSOM MODEL

Only one longitudinal frame (the frame 4 ft off centerline to starboard) was instrumented in the transom region (see Fig. 6 for a drawing of the structural arrangement). In Fig. 12 is shown the basic finite element mesh model, which includes transverse frames 2 and 4 and the shell plating connecting both adjoining longitudinal frames. Since the scantlings of the ship's transom structure above the waterline are much less than the underwater scantlings it was decided to approach the transom model as a tapered cantilever beam. An initial model was used to determine the response and stiffness of the adjoining longitudinal frames at 2 ft and 6 ft off centerline to starboard. The computed stiffnesses were used to add spring finite elements along the edges of the model where the two adjoining longitudinal frames would be. Since five strain gages were placed on the actual ship's frame, five loading conditions were used and responses were obtained at all five gage locations.

3.7 CONSTRUCTION OF THE DATA REDUCTION MATRICES

The data reduction matrix (the inverse of the influence matrix) is the heart of the system. It involves an algorithm that converts the measured strains on an instrumented panel into an ice impact pressure distribution. The algorithm is based on the premise that the ice load on the panel can be sufficiently approximated as a group of distinct uniform pressures each acting over an area of the hull. On the bow panel of the *Nathaniel B. Palmer* these subpanels are approximately 20.8 x 16 in. (52.8 x 40.6 cm). The subpanel sizes for the other instrumented hull panels are roughly the same as for a subpanel on the bow, and their dimensions are given in Table 3. Further refinement of the ice pressure over a smaller area was not needed since the smallest area of interest was one subpanel, and an average ice

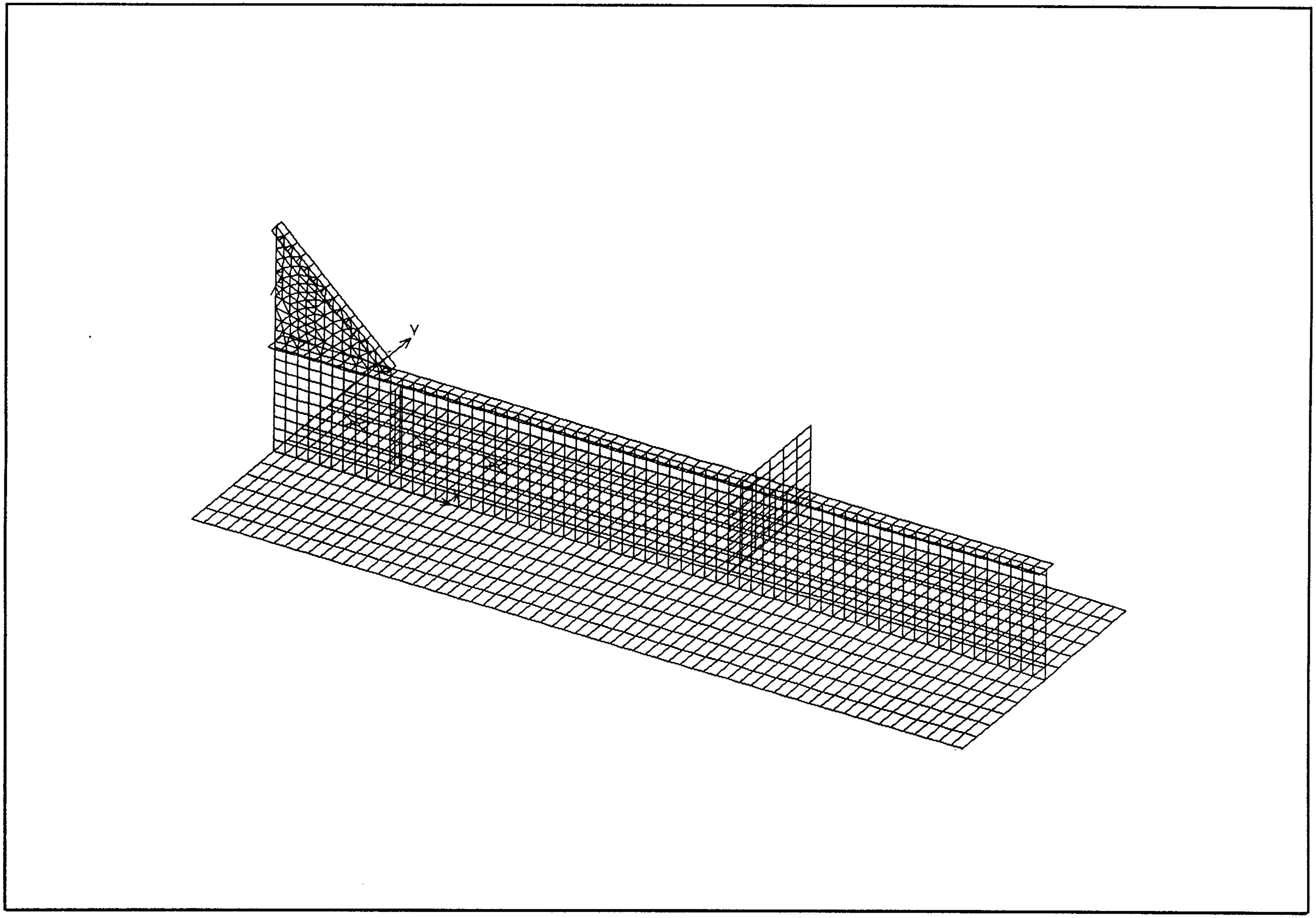


Figure 11. Finite element mesh of frame 39 (single frame model).

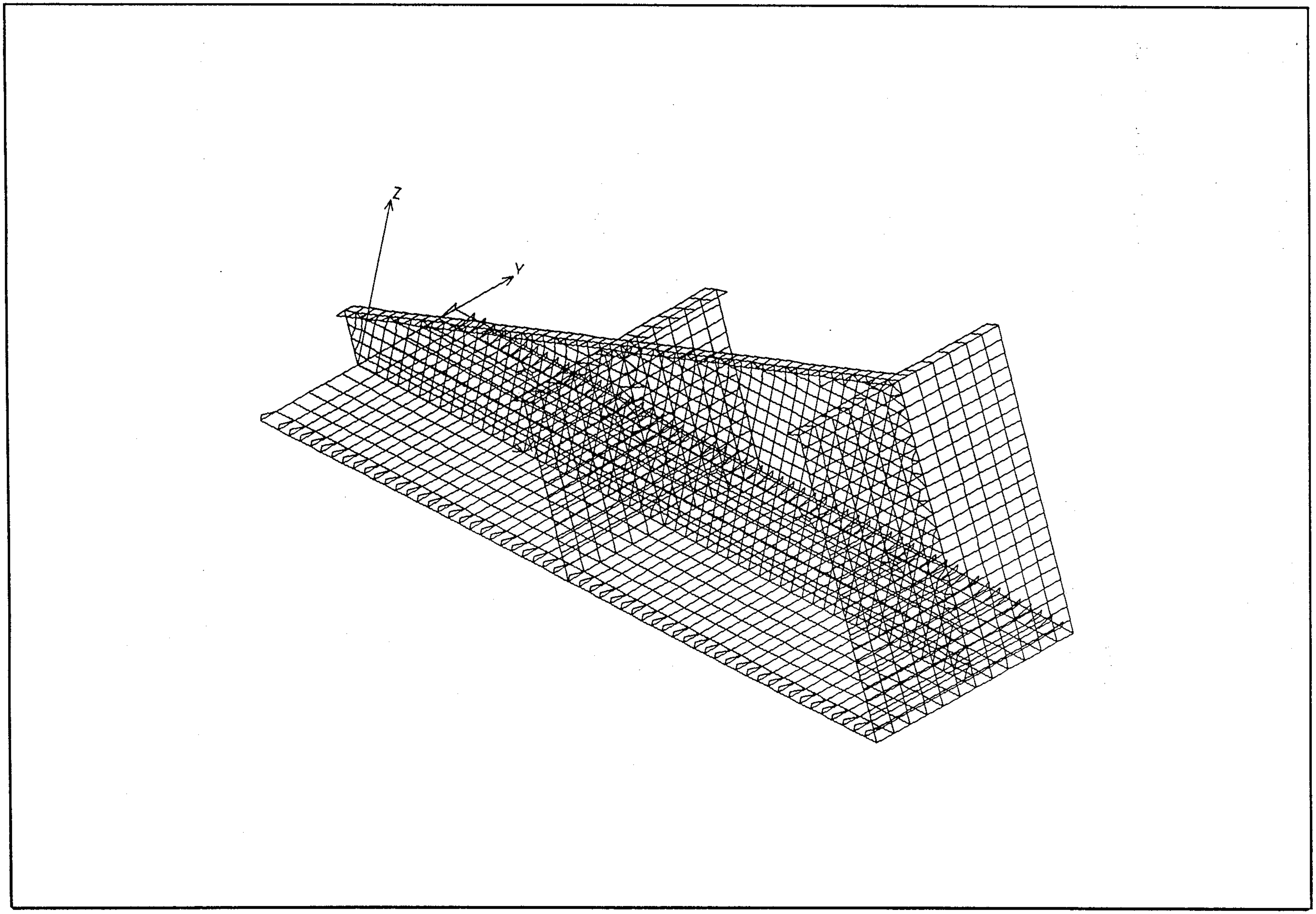


Figure 12. Finite element mesh of transom longitudinal girder 4 ft off centerline to starboard.

pressure over this area is generally sufficient for the design of icebreaker plating and framing. The averaging of more and more of these individual subpanel pressures gives the average pressure for larger areas that are of interest in the design of the internal scantlings.

Taking the bow panel as an example, which is six subpanels high by seven subpanels wide, the actual ice load algorithm transformed 42 measured strains into 42 distinct uniform pressures using the inverse of an influence matrix [K]. In matrix formulation

$$\underset{42 \times 1}{\{\text{Strains}\}} = \underset{42 \times 42}{[K]} \cdot \underset{42 \times 1}{\{\text{Pressures}\}} \tag{1}$$

where the strains and pressures for the whole panel are each given as vectors containing 42 elements. Inverting the above equation gives the data reduction matrix $[K]^{-1}$

$$\underset{42 \times 1}{\{\text{Pressures}\}} = \underset{42 \times 42}{[K]^{-1}} \cdot \underset{42 \times 1}{\{\text{Strains}\}} \tag{2}$$

where each column in the influence matrix [K] represents the 42 strains that resulted from the application of a unit pressure on one subpanel in the model. The large matrix [K] can be constructed by the superposition of smaller 6 x 6 matrices [k] for each frame and relate the strain at the 6 gage locations to a uniform pressure over the subpanel area for each gage on the frame. The across web influences are handled by adding off-diagonal terms of appropriate magnitude, which are some fraction of the diagonal terms. A reaction of 10 percent at the neighboring frames would result in a [K] matrix of the following formulation

$$[K] = \begin{bmatrix} [k] & [0.1k] & [0.01k] & & [10^{-6}k] \\ [0.1k] & [k] & [0.1k] & & [10^{-5}k] \\ [0.01k] & [0.1k] & [k] & & [10^{-4}k] \\ & & & & \\ [10^{-6}k] & [10^{-5}k] & [10^{-4}k] & & [k] \end{bmatrix} \tag{3}$$

For the bow panel influence matrix, the reaction at the neighboring frames was approximately 12 percent of the reaction under the loaded frame, but the actual reactions were computed using a multiple-frame finite element model and incorporated into the development of the influence matrix.

Separate influence matrices were constructed for each of the instrumented hull panels. The form of these matrices for the bottom, side, and transom hull panels is as shown above, but they are considerably smaller since fewer strain gage pairs are involved. Each of the completed influence matrices was inverted to yield its respective data reduction matrix. The actual data reduction matrices are given in Appendix C.

4. SUMMARY OF THE DATA COLLECTED

4.1 DESCRIPTION OF THE TRIP AND THE ROUTE

The deployment of the R/V *Nathaniel B. Palmer* in the Antarctic winter ice tests took place during the latter part of August and early half of September 1992, at which time the vessel transited from Punta Arenas in southern Chile to the South Orkney Islands in the Weddell Sea, across to the South Shetland Islands off the Pacific side of the Antarctic Peninsula, and back across the Drake Passage to Chile. The ship sailed during late winter for this region, when the ice extent in the Weddell Sea was expected to be at its most northerly extent. An overview of the *Palmer's* track taken from the noon position reports is given in Fig. 13.

The *Nathaniel B. Palmer* departed Punta Arenas on the 23 August 1992. Open water resistance and seakeeping data were collected during the open water transit to the ice edge in the Weddell Sea. Waves in the Drake Passage were moderate with a maximum of sea state 6 (Beaufort 8). Ice conditions just beyond the ice edge in the Weddell Sea were more severe than anticipated, resulting in slow progress. The ice conditions were found in the vicinity of the South Orkney Islands and were typically 90 to 100 percent coverage of 2- to 4-ft (0.6- to 1.2 m) thick ice with about 10 to 20 percent concentration of ice greater than 4 ft (1.2 m) in thickness. Several of the thicker floes were profiled and determined to be 6 to 13 ft in thickness. The vessel continued southward into the ice, and at a point southeast of the South Orkney Islands, indicated in Fig. 14, a decision was made to look for level ice in the bays and inlets nestled in these islands. The transit westward, south of the Orkneys, was slow and Lewthwaite Strait (between Coronation and Powell Islands) was selected for closer examination during the early morning hours of 30 August. Unfortunately, except for dozens of grounded bergs, only open water was found in the strait. Upon the *Palmer's* departure on a route southeasterly from the islands, heavy ice conditions again proved to make for a difficult transit. Operations in heavy ice were further hampered by lateral ice pressure in the pack. Ice drift measurements in this area revealed only very slight movement of the ice due to the constraining effects of the South Orkney Islands on the pack ice. Several days of fighting these ice conditions were required until the vessel cleared the southeast corner of the islands.

At this point an assessment was made of data obtained and data still desired for all of the onboard measurement programs. This led to the decision to proceed to King George Island in the South Shetland Islands in search of thinner, uniformly level ice for more controlled level ice resistance tests and hull impact loads measurements in lighter ice conditions. Excellent

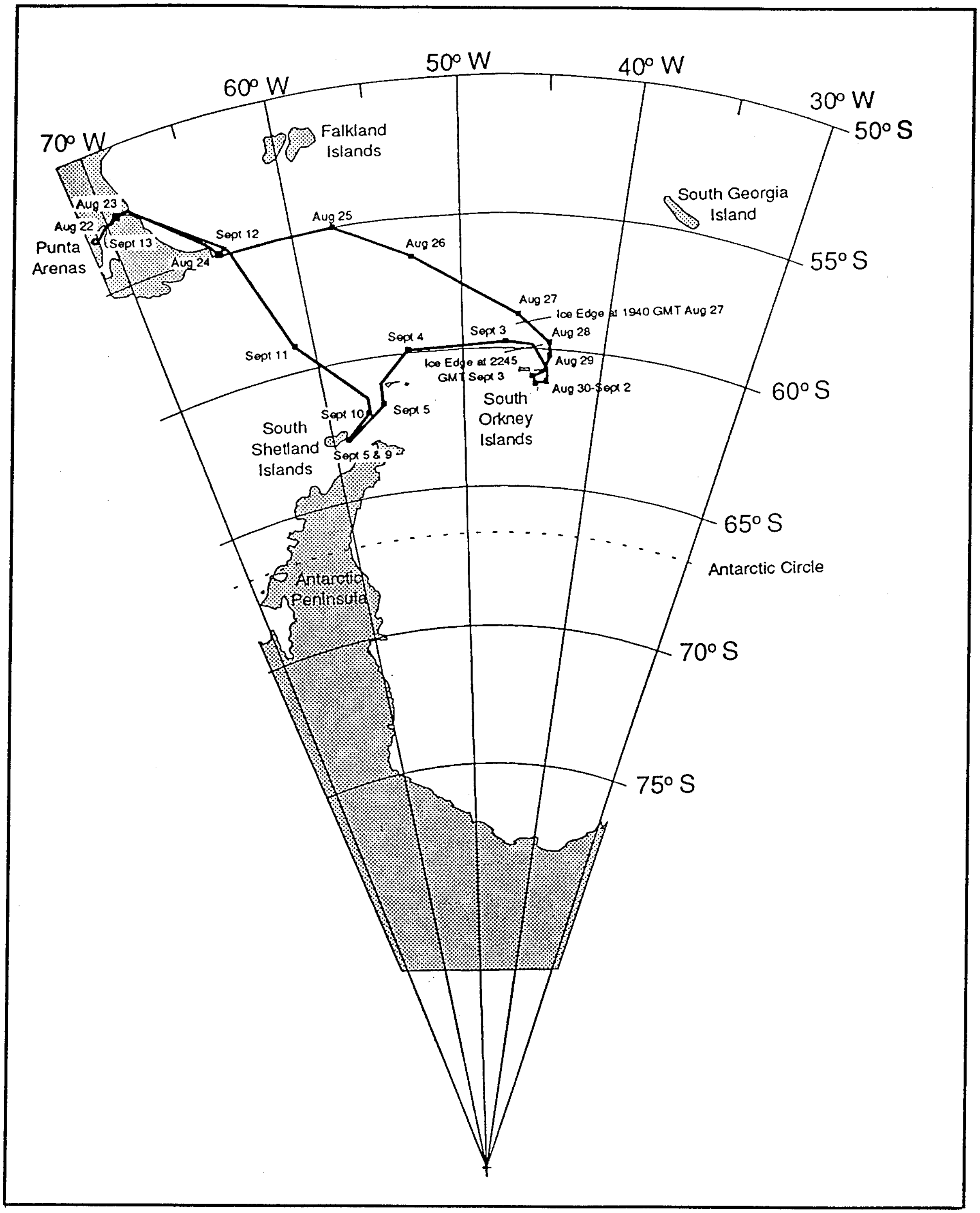


Figure 13. Daily noon positions for *Nathaniel B. Palmer* winter ice tests.

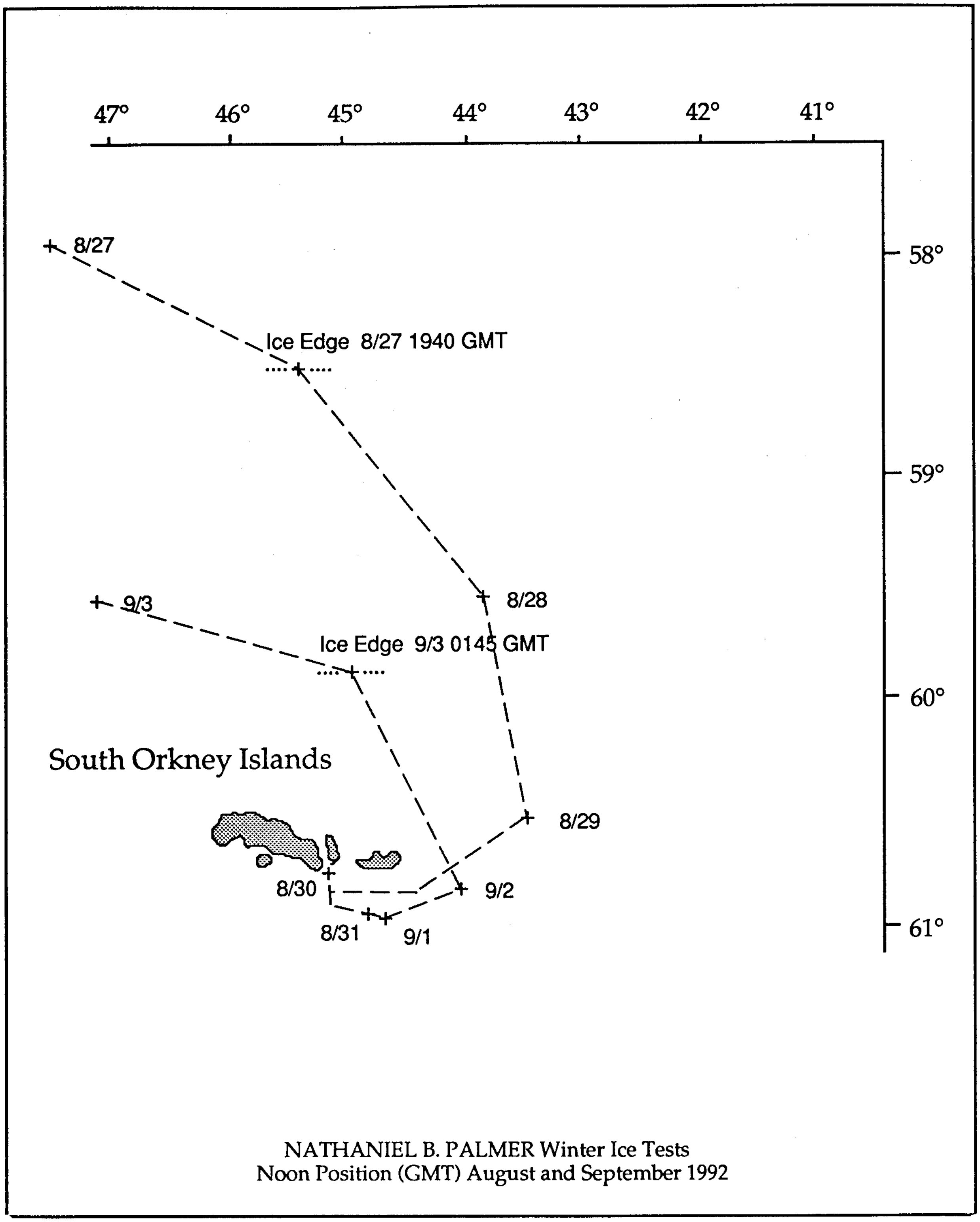


Figure 14. Vicinity of South Orkney Islands.

level ice conditions were found in Maxwell and Admiralty Bays on the coast of King George Island yielding a very satisfactory collection of ice performance tests between 6 and 9 September.

Additional seakeeping tests were performed during the transit back to Punta Arenas, but the comment was made that the Drake Passage should be renamed the "Drake Lake." The *Nathaniel B. Palmer* arrived back at Punta Arenas on the morning of 13 September 1992.

4.2 DESCRIPTION OF THE ICE CONDITIONS

The *Palmer* encountered two different types of ice conditions on the deployment. The first and heavier ice conditions were found in the vicinity of the South Orkney Islands and were typically 90 to 100 percent coverage of 2- to 4-ft (0.6- to 1.2-m) thick ice with about 10 to 20 percent concentration of ice greater than 4 ft (1.2 m) in thickness. The average flexural strength was determined to be 75 psi (515 kPa) according to Vaudrey's formulation for ice strength from brine volume (Vaudrey, 1977). The ship encountered a second set of ice conditions when testing was performed in the landfast ice of the bays of King George Island in the South Shetland Islands. This ice was 1 to 2 ft thick with an average flexural strength of 79 psi (545 kPa).

Ice properties data were measured concurrently with the performance tests and whenever interesting sea ice was observed and time was available. In most cases, temperature and salinity samples were taken from ice cores at increments of 10 cm (4 in.) down the length of the core. This allowed the ice flexural strength to be computed using Vaudrey's method. In addition, a number of beams were cut from the ice and tested for flexural strength either at the site or brought back onboard the *Palmer* for testing in a temperature controlled cold room. In Table 4 a summary is presented of all the ice properties obtained during the deployment. Since the ice properties measurements and performance testing occurred during daylight hours, the location of each site can be determined by comparing the date with the GMT noon (0900 ship time) positions shown in Figs. 13 and 14. Referring to Table 4, the first ice sample was taken shortly after entering the ice with the relatively warm saline ice giving a low flexural strength of 22 psi (152 kPa).

The snow depth and temperature were measured along with the ice cores and beam samples. Snow samples were taken to determine the density and compactness of the snow.

Table 4. Summary of Ice and Snow Properties (from Williams, 1992)

DATE	SITE	ICE			ICE STRENGTH							
		Thick.	Temp.	Sal.	Beams In Lab.		Beams In Situ		Vaudrey		Surface Hard.	
		(m)	(°C)	(ppt)	(kPa)	(psi)	(kPa)	(psi)	(kPa)	(psi)	(MPa)	(psi)
8/27/92	IE1	0.91	-1.4	6.52	659	96			152	22	15	2175
8/28/92	IE6	4.05	-3.0	2.53	572	83			569	83		
8/29/92	RM1	1.32	-3.2	3.31	705	102			527	76	19	2755
8/31/92	RM5	2.25	-6.6	3.89	628	91			627	91		
8/31/92	RM23	1.26	-3.3	4.59	689	100			374	54	25	3625
9/1/92	RM26	2.15	-3.6	3.33	584	85			542	79	25	3625
9/6/92	LR5	0.46	-4.1	3.47	525	76	387	56	570	83	20	2900
9/6/92	LR9	0.48	-4.0	3.00	593	86			596	86		
9/6/92	LR16	0.52	-4.5	4.27	586	85	358	52	540	78	17	2465
9/7/92	LR23	0.57	-4.0	5.30	469	68	350	51	470	68		
9/8/92	LR32	0.61	-1.7	1.69	705	102	526	76	564	82	28	4060
9/9/92	LR40	0.57	-2.9	3.03	705	102	550	80	511	74	28	4060

DATE	SITE		SNOW								Air
			Thick.	Temp.	Compactness		Density		Classification		Temp.
			(m)	(°C)	(kPa)	(psi)	(kg/m^3)	(lbf/ft^3)	(#)		(°C)
8/27/92	IE1		0.30	NA							3.1
8/28/92	IE6		0.98	-0.44	30.4	4.4	325	20.3	5		-2.4
8/29/92	RM1		0.27	-3.40	114.8	16.6	333	20.8	5		-1.0
8/31/92	RM5		0.72	-15.80	98.5	14.3			4		-21.1
8/31/92	RM23		0.38	-8.80	73.0	10.6	394	24.6	4		-14.4
9/1/92	RM26		0.52	-5.90	68.9	10.0	355	22.2	3		-3.2
9/6/92	LR5		0.07	-5.10	106.0	15.4	348	21.7	5		-7.2
9/6/92	LR9		0.11	NA							-6.0
9/6/92	LR16		0.10	NA							-7.4
9/7/92	LR23		0.08	NA							-5.7
9/8/92	LR32		0.06	-1.50			374	23.3	3		-8.8
9/9/92	LR40		0.11	-1.50	189.8	27.5	437	27.3	3		0.5

Notes: Numbers are averages for each site.
Beams in laboratory - 1 m x 0.1 m x 0.1 m
Beams in situ - 2 m x 0.5 m x thickness
Vaudrey: Vaudrey formula based on temperature and salinity.
Hardness: Indentation hardness of ice.
Compactness: Energy/unit volume to compress snow.

These results are also summarized in Table 4. The snow classification number is described by Williams et al. (1992a), but generally runs from 1 for slush and 2 for no snow to increasingly higher numbers for colder, more compact snow cover. As the value of the snow number increases, the effect of snow friction also increases.

Trafficability data including observations of ice conditions were obtained and recorded every hour that the ship was transiting through the ice. A summary of the representative ice conditions in the vicinity of the South Orkney Islands is shown in Fig. 15.

4.3 SUMMARY OF THE ICE IMPACT DATA

The hull monitoring system for the collection of ice loads impact data was kept running whenever the *Nathaniel B. Palmer* was operating in ice. In Table 5 a summary is given of the ship's activities and the status of the data collection system. In the table is also shown the threshold settings used on each of the hull panels and how these were adjusted depending upon the ice conditions and the distribution of events between the panels. When the *Palmer* first entered the ice north of the South Orkney Islands, the threshold settings were set at what was felt to be reasonable but high levels in order to get a feel for the frequency of event logging depending upon the type of ice. The thresholds were lowered in stages until a reasonable distribution of events were recorded on the bow, side, and transom panels. Generally speaking, the bow panel threshold was kept higher than the other thresholds because of the higher frequency of impacts on the bow and the desire for the system to be more sensitive to events on the other panels. The hull monitoring system was left unattended and checked every half hour or so while transiting in ice; however, the system was manned and all threshold settings were lowered during dedicated ramming, level icebreaking, and maneuverability tests.

A total of 720 impact data records were obtained during the deployment. Obviously the great majority of the events were recorded in the vicinity of the South Orkney Islands where the *Palmer* spent some time working her way out of the packed ice south and east of the islands. Upon reviewing the data channel by channel, however, a fair number of event records were discovered to include simultaneous impact events on more than one panel. In other words, the impact on one panel would trigger an event, while a very short time later another panel would experience a triggerable event. Since all 59 data channels were recorded no matter which panel triggered the event, the simultaneous impact was also captured. This happened most frequently with the side and bow panels, but it also occurred with the other

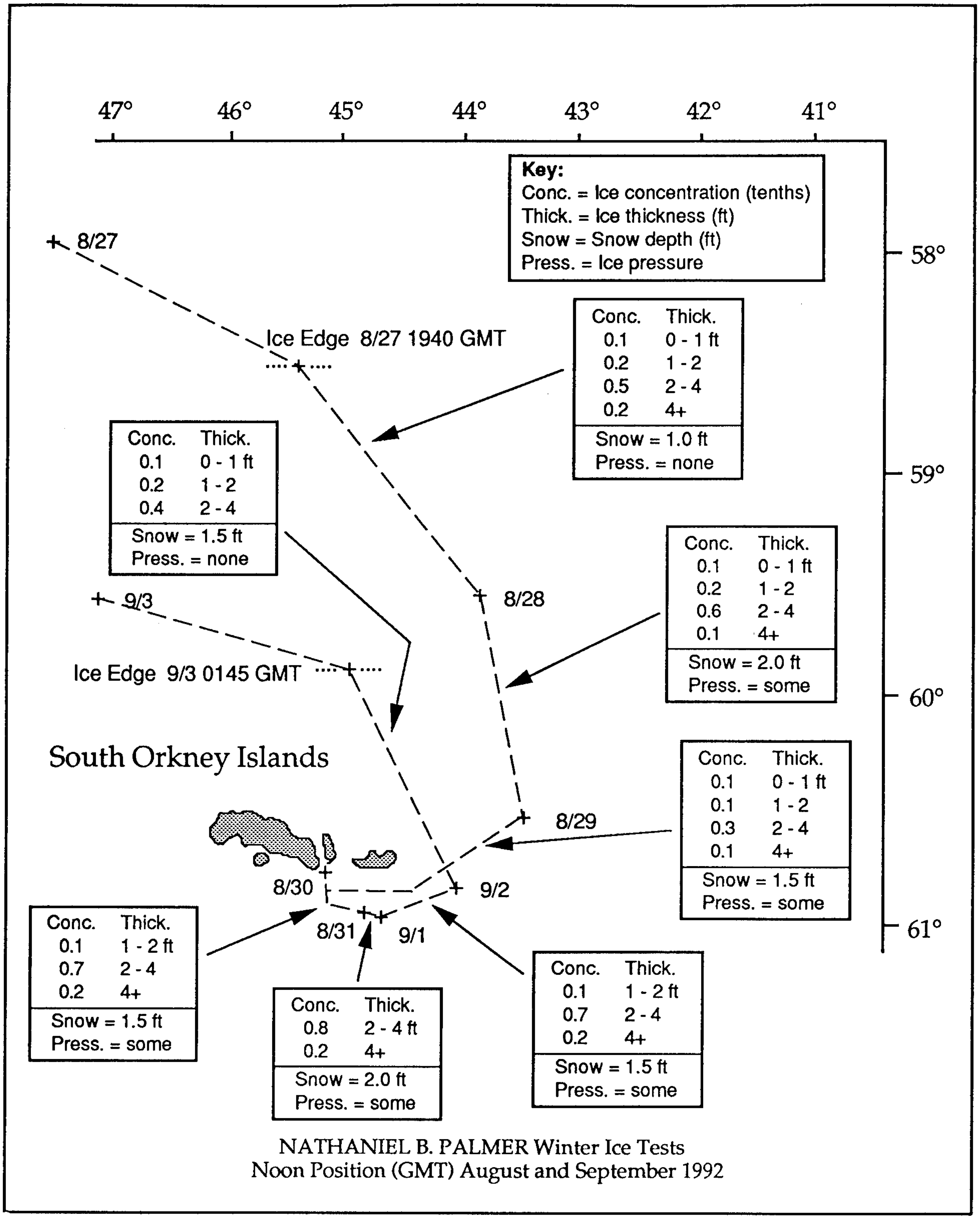


Figure 15. Representative ice conditions along the route.

Table 5. Hull Loads Data Acquisition Log Sheet

Start Date	Start Time (GMT)	End Date	End Time (GMT)	Threshold Settings Bow (με)	Bottom (με)	Side (με)	Transom (με)	Comments
8/27/92	20:30	8/28/92	11:30	50	50	50	50	Started DA system running.
8/28/92	11:30	8/28/92	14:00	40	40	40	40	No events recorded. Adjusted thresholds downwards.
8/28/92	14:00	8/28/92	16:00	40	40	40	40	Changed Bow trigger from Chn 8 to Chn 1.
8/28/92	16:00	8/29/92	02:00	25	25	25	25	Reduced thresholds. Bow trigger back on Chn 8.
8/29/92	02:00	8/29/92	12:00	30	30	30	30	Trigger thresholds set to 30 microstrain.
8/29/92	12:00	8/30/92	05:50	25	25	25	25	Reduced thresholds to 25 microstrain.
8/30/92	05:50	8/31/92	00:00	25	25	25	25	Added trigger to bow. Now triggers on Chn 7 & Chn 8.
8/31/92	00:00	8/31/92	09:00	30	20	20	20	Adjusted triggers.
8/31/92	09:00	8/31/92	10:23	30	20	20	20	Bow triggers set to Chn 7 & Chn 16.
8/31/92	10:23	8/31/92	13:38	25	15	20	15	Adjusted triggers.
8/31/92	13:38	8/31/92	13:56	25	10	15	10	Adjusted triggers for dedicated ramming tests.
8/31/92	13:56	8/31/92	14:30	25	7.5	10	7.5	Adjusted triggers for dedicated ramming tests.
8/31/92	16:46	8/31/92	17:27	25	7.5	7.5	7.5	Adjusted triggers for more dedicated ramming tests.
8/31/92	17:27	8/31/92	18:00	25	5	5	5	Adjusted triggers.
8/31/92	20:15	8/31/92	20:41	25	7.5	7.5	7.5	Adjusted triggers for "level" ice resistance tests.
8/31/92	20:41	8/31/92	23:15	25	5	7.5	5	Adjusted triggers.
8/31/92	23:15	9/1/92	03:00	30	5	10	10	Adjusted triggers.
9/1/92	10:30	9/1/92	15:00	30	5	10	10	Startup after being stopped for the night.
9/1/92	15:00	9/1/92	16:00	30	5	10	10	Started ramming profiled floe.
9/1/92	16:00	9/2/92	13:45	30	5	15	10	Adjusted triggers after many side events logged.
9/2/92	14:23	9/2/92	15:00	30	5	15	10	Stopped DA system because of open water.
9/2/92	20:15	9/3/92	02:00	30	10	15	10	Adjusted triggers. Passed through band of ice in MIZ.
								Secured DA System. U/W enroute King George Island.
9/5/92	15:22	9/6/92	01:30	30	10	15	10	Crossing MIZ enroute King George Island.
9/6/92	11:00	9/6/92	13:30	25	10	15	10	Arrived Maxwell Bay and Level Ice.
9/6/92	13:30	9/6/92	14:13	20	7.5	10	7.5	Maxwell Bay - 1.5 ft Level Icebreaking Tests
9/6/92	14:13	9/6/92	16:44	20	7.5	15	7.5	Many side events. Adjusted Triggers.
9/6/92	17:34	9/7/92	20:20	20	10	15	10	Maxwell Bay - 3.0 ft Level Icebreaking Tests
9/8/92	12:30	9/8/92	21:30	15	10	10	10	Admirality Bay - Level Icebreaking Tests.
9/9/92	13:20	9/9/92	21:00	15	10	10	10	Level Icebreaking Tests.
9/9/92	21:00	9/9/92	23:45	20	10	15	10	Departing King George Island.
9/9/92	23:45	9/10/92	12:00	30	30	30	30	Enroute Punta Arenas. Triggers set artifically high.

two hull panels. In 3 cases, triple simultaneous events were captured. Out of the 720 data records, there were 796 good impact events. The breakdown is as follows:

Recorded Events	720
Drift or Spike Triggers (no data)	- 54
Good Primary Events	666
Good Simultaneous Events	+130
Total Impact Events	796

A daily tally of the number of actual impact events logged is shown in Fig. 16. Appendix D contains two chronological summaries listing all the recorded events. The first (Table D-1) identifies the location of the primary impact location, indicates whether simultaneous events are contained on the record, and gives some indication of the quality of the event. For instance, some of the events had multiple peaks during the course of the impact, or were of an extra long duration. This summary in the appendix also notes the number of frames that were loaded for the bow panel during the impact, which gives a rough indication of the size of the impact. Another indication of impact size is the peak strain recorded over all time steps and all channels for an event. This is noted in Table D-1 by a column indicating the peak microstrain and the channel number.

A listing of key impact parameters is summarized in Table D-2 of Appendix D for all the 796 actual impact events with a correlation between an impact's consecutively assigned event number and its original data record number. Simultaneous events were assigned their own event number and reduced separately.

As noted in the event breakdown, 54 triggered "events" were the result of channel drift or spikes rather than an actual impact. The trigger from a channel drift occurred most frequently on the bottom panel where the threshold settings were purposely set low to capture small impacts. Other problems with the raw data include arbitrary spikes, minor interference, and channel shifting, but these were removed or corrected before the raw data were analyzed. Small amounts of interference occurred most often at the transom location and may have been due to one of the steering pump motors starting and stopping. At times portions of the data on a pair of analog-to-digital boards were found to be shifted by one or more channels. The source of this problem is unknown, but the occurrence of channel shifting is obvious and was corrected before data analysis. In addition, 23 events had arbitrary spikes on one of the channels, but this problem was also easily corrected. One software "bug" was detected early

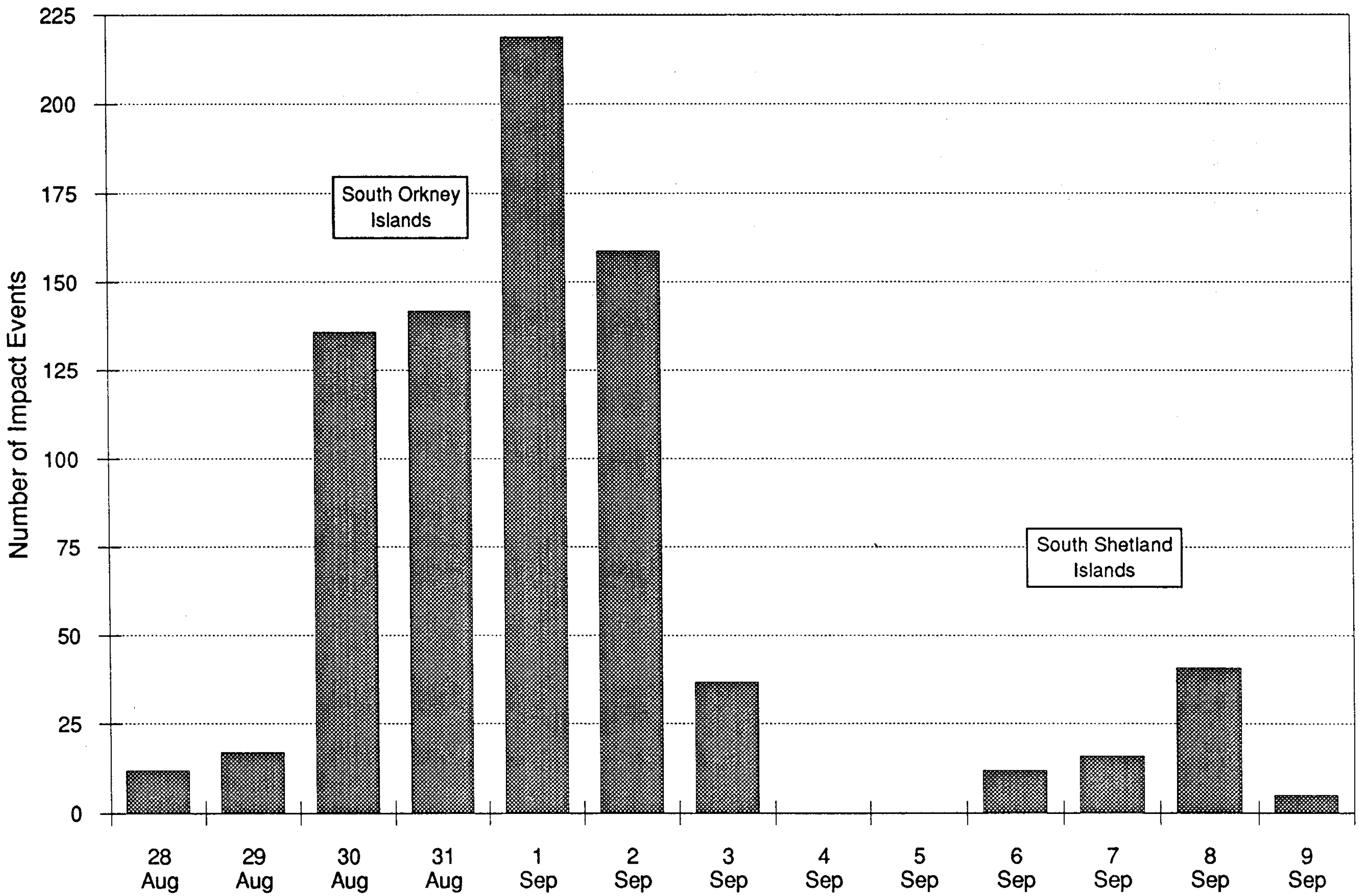


Figure 16. Summary of impact events by day.

in the deployment whereby only the channels on the first analog-to-digital card were being sampled and recorded. The result was that only bow panel events on the forwardmost three frames were recorded for these events. This problem was discovered as the recorded data from the first couple of days were being reviewed and cataloged. It was corrected and no further difficulties of this type were encountered. All of the situations discussed here are noted on a data record by data record basis in Table D-1 of Appendix D.

A summary of the number of events by hull panel and geographic location is given in Table 6. The secondary, or simultaneous, events are included in the tabulation. As expected the greatest number of events was recorded from the bow panel even though the trigger channel threshold was set higher here than for the other locations. The side panel logged the second greatest number of events with about 27 percent of the total. This was followed by the transom frame with 7 percent. The bottom panel did record some events but only about 2 percent of the total.

Table 6. Summary of Impact Events Recorded by Geographic Location and Hull Panel

Hull Panel	South Orkney Islands		King George Island		Total
	Primary	Secondary	Primary	Secondary	
Bow	416	54	25	16	511
Side	148	37	26	6	217
Transom	46	6	0	1	53
Bottom	5	10	0	0	15
Total	615	107	51	23	796

5. REDUCTION OF THE DATA TO LOADS AND PRESSURES

5.1 DESCRIPTION OF THE DATA REDUCTION PROCEDURE

The raw data that were collected during an ice impact on any of the panels consisted of a 59-channel strain time-history of all the gages sampled 31 times per second for 5 sec. The data were collected whenever the strain on any of the designated trigger channels exceeded the preset threshold strain shown in Table 5. Each exceedance of a threshold value triggering the recording of a fixed amount of data from the 59 channels was designated as a data record. If the loads remained high during an impact and therefore the strains, several data records could be recorded for a single impact. In addition, several of the recorded events triggered from one hull panel also captured simultaneous events occurring on one of the other hull panels, as described above. This happened most frequently with the bow and side panels. These data records were divided and treated as two separate events during the analysis.

Impact events were automatically recorded on 3.5 in. computer disks with 10 events per disk. The first step in the analysis process was to review the strain time-histories for each of the channels and rezero the channels as needed to correct for any sensor drift. During this process the data records were further evaluated as to event location, quality, and magnitude of the impact, and the occurrence of multiple panel events. Sequential event numbers were assigned at this point to every ice impact noted in the rezeroed data records. Data records resulting from spikes or interference were skipped and simultaneous impacts on different panels were assigned different event numbers. Table D-2 contains a cross-reference between the data record numbers and event numbers.

Finally, the rezeroed data were analyzed using the data reduction or influence matrices generating a reduced data set that consisted of a 42-, 6-, or 5-channel pressure time-history for each event depending upon the hull panel size. In addition, a summary file was generated that included the pressure versus area description, pressure versus length, and pressure versus height along the hull. These pressure curves were selected for the time of peak force and the time of peak pressure on a single subpanel. Pressure-area relationships were generated for a particular time-step by first finding the subpanel with the highest pressure, then looking for the adjacent subpanel with the highest pressure of all the neighboring subpanels. This process was continued until the entire loaded contact area was searched. The reduced data set was stored for subsequent data analysis. Reduced data plots for each event are given in a 19-volume companion report subtitled "Reduced Data Plots for Each Event" (St. John and Minnick, 1993b). Examples are given in the next section. Appendix E

contains a listing of the highest single subpanel pressures at the times of peak pressure and peak force, the maximum hull panel local load, and the maximum frame load measured for each impact event.

Observed ice conditions and the ship's average velocity were recorded at all times the ship was transiting in ice. The data logging or collection procedures were relatively straightforward in the sense that a number of observations were made from the pilothouse during each 1-hr time period and average values for the observations were noted on a data sheet. In addition, Global Positioning System (GPS) data were recorded continuously, and through later analysis, converted into speed time-histories. Both sets of data were reviewed and correlated with the impact event times. This information may be found in Appendix E for each impact event.

5.2 EXAMPLES OF REPRESENTATIVE HULL-ICE IMPACT EVENTS

As pointed out in the previous section, the raw data have to be displayed channel by channel and rezeroed to eliminate sensor drift. The process also helps to view the quality of the data. Figures 17 and 18 show how the rezeroed strain time-histories appear for two events, one on the bow panel and one on the side. For each event 10 strip charts are produced with six channels of data overlaid for each chart. Since each bow frame had six channels of data, all channels for a frame were plotted together. This plotting technique is shown in Fig. 17 where CF 124 is the forwardmost and CF 118 the aftermost. The full 5 sec of the time-history are given on the horizontal axis and the vertical axes are in microstrain. The impact is seen to hit CF 124 first, loading each of the frames in turn as the ice moves aft and off the panel. The strain builds in magnitude until the peak of 190 $\mu\varepsilon$ is reached on CF 121 (channel 21) and then decays. Also note that for any given instance of time during the impact three frames are loaded simultaneously, which is an indication of the horizontal extent of the load. This is event No. 5 (data record No. 4) as given in the summary in Appendix D. Figure 18 shows event No. 39 (data record No. 44), which occurred on the side panel. There are six gage channels divided between the two frames on the side, so they were all plotted together on the strip chart. However, it is still possible to see that first one frame was loaded before the second one was loaded, and that for a brief time in the middle of the impact event both frames were loaded simultaneously.

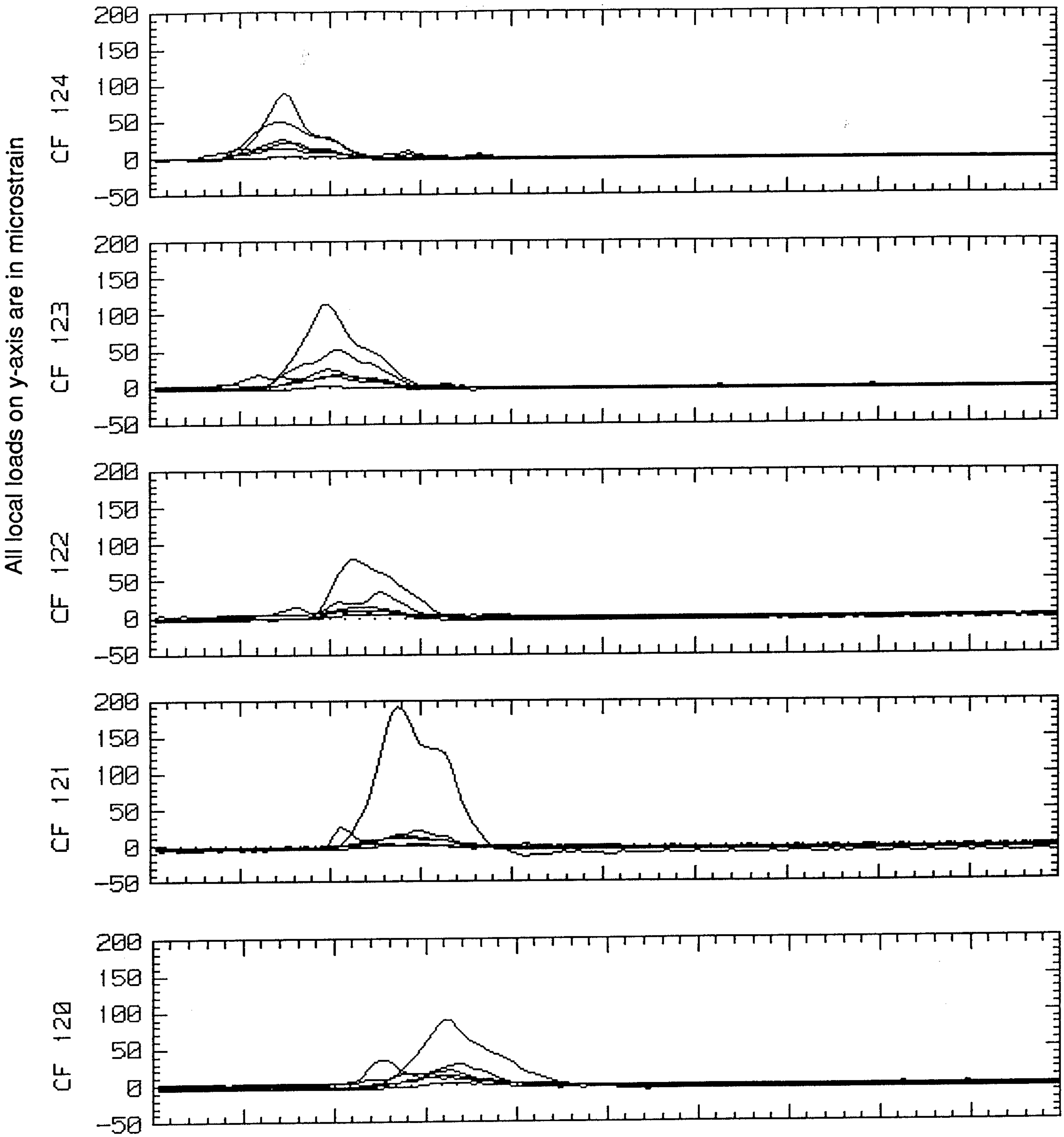


Figure 17. Measured strains on bow panel for event No. 5.

All local loads on y-axis are in microstrain

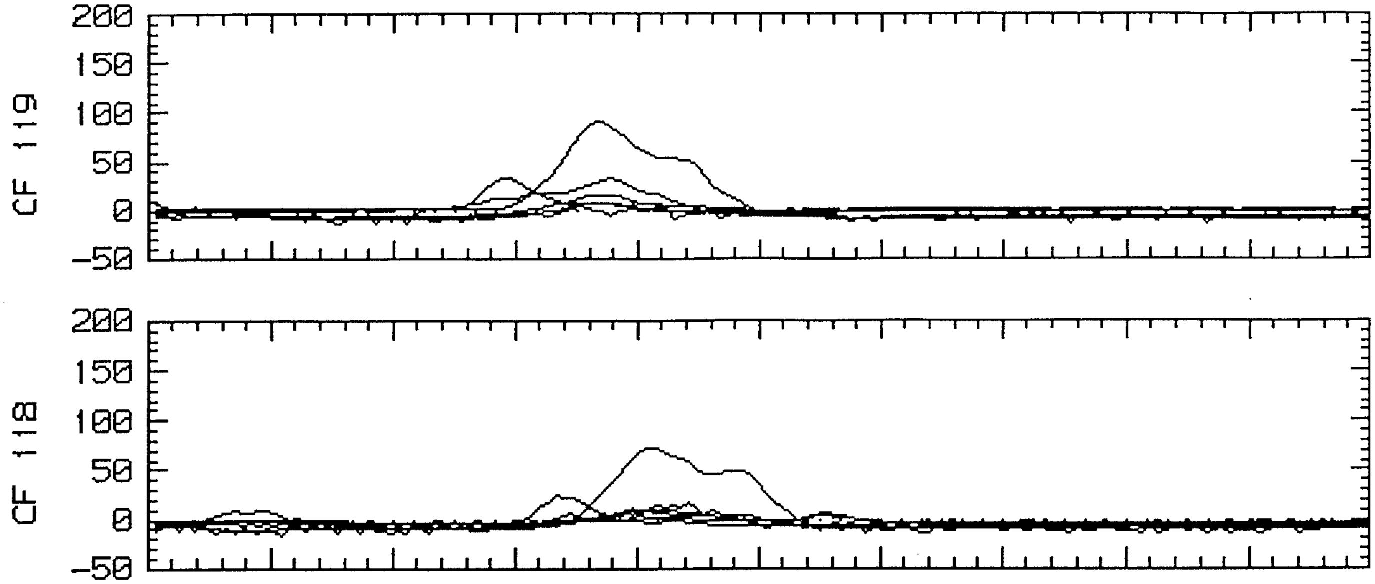


Figure 17. Measured strains on bow panel for event No. 5 (Continued).

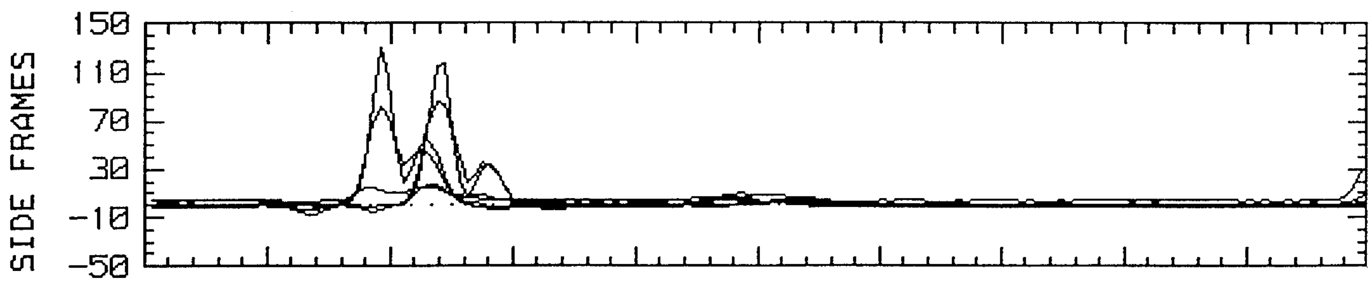
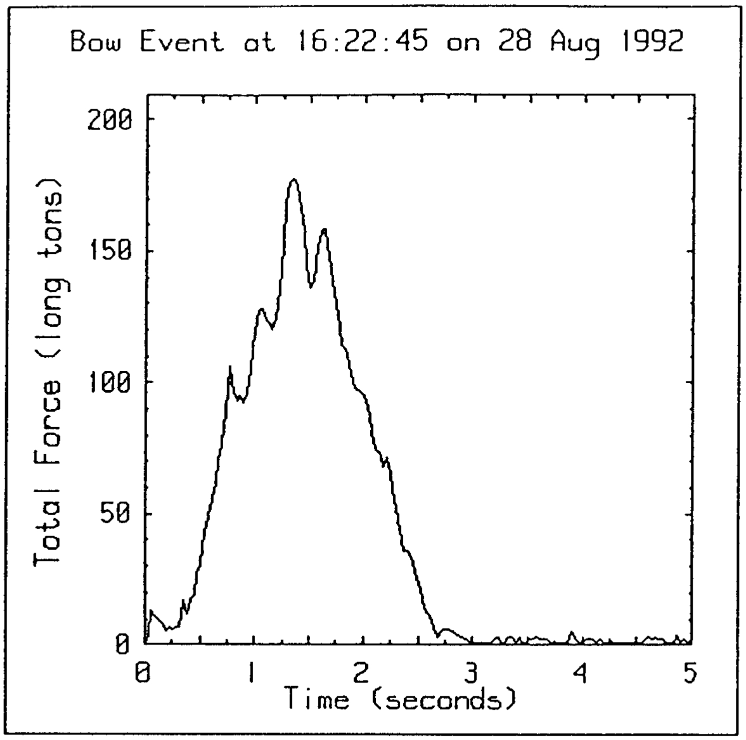


Figure 18. Measured strains on side panel for event No. 39.

The same two events of Figs. 17 and 18 are shown in Figs. 19 and 20 after being reduced using the appropriate data reduction or influence matrices. The upper graph in each of these figures is a force time-history over the 5-sec recording period of the event; the lower graph gives two pressure-area curves, one for the time of peak pressure on a single subpanel (dotted line) and the other for the time of peak force (solid line). Figure 19 represents an impact on the bow panel (event No. 5) where the total impact force on the panel achieved almost 180 LT (1.8 MN). The pressure-area curves both show a fairly straight line on the log-log plot approaching a slope consistent with a line of constant force. A pressure asymptote for the smaller areas is not apparent on these particular plots.

Figure 20 is a smaller impact measured on the side panel (event No. 39). In this case, the force time-history shows two peaks with the higher peak reaching almost 65 LT (0.65 MN). The lower graph shows pressure-area curves that both have a more typical shape flattening out at small areas.



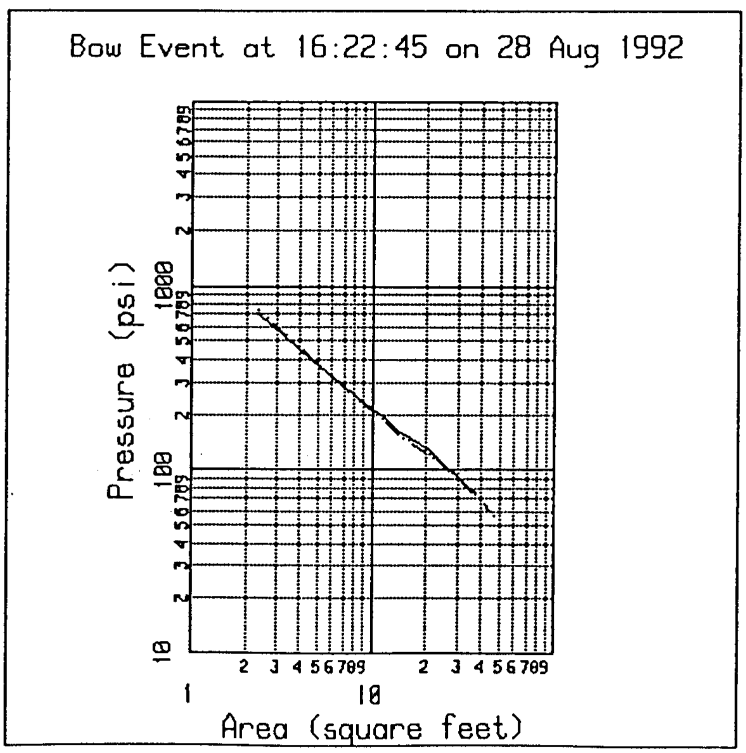


Figure 19. Representative bow panel impact event (event No. 5).

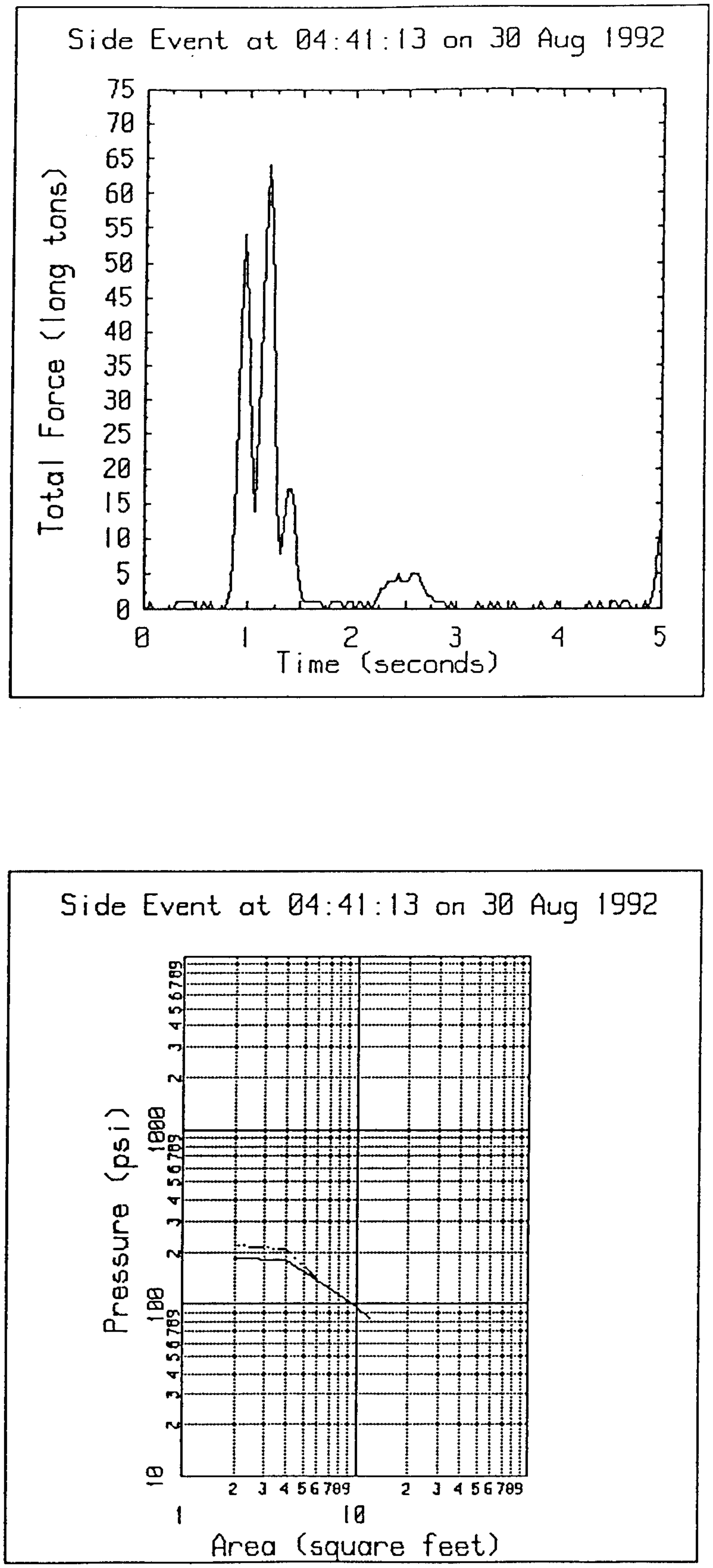


Figure 20. Representative side panel impact event (event No. 39).

6. ANALYSIS OF THE REDUCED DATA

After the data were reduced to engineering units, the data were analyzed by plotting the pressures and forces against the important variables. Individual impact pressures were rank ordered, plotted, and regressed as extreme value distributions. The data were also analyzed as to the extent and shape of the contact area during the impact. Results of this effort are presented in the following sections.

6.1 SUMMARY OF THE PEAK EVENTS

It is interesting to examine the time-histories of some of these extreme events to understand the shape of the pressure distribution on the hull. Segments of the time-histories of two different bow panel impact events are shown in Figs. 21 and 22. The bow of the ship is to the left in the figures and the smaller numbered waterlines are closer to the ice surface. The impact on August 28 at 16:22:45 shown in Fig. 21 was a quite localized event and recorded the highest pressure for a single subpanel area for the trip. The event involves significant loading of only three frames. The peak pressure of 735 psi (5.07 MPa) over one subpanel occurs at time step 43. The peak force occurs at time step 42 and is 178 LT (1.77 MN) over 11 significantly loaded subpanels or 25.4 ft^2 (2.36 m^2). The average pressure over those 11 subpanels at that time was 107 psi (0.74 MPa). The time steps are 0.032 seconds apart (about 31 Hz sampling) so the entire time-history occurs in 0.48 seconds.

A second example is the event on September 1 at 00:01:03 shown in Fig. 22. This event is the highest total load on the bow panel that was recorded and demonstrates a line-type loading. The peak pressure was 453 psi (3.12 MPa) during time step 34 and the peak load on the whole panel occurred at the same time step. The peak force was 236 LT (2.35 MN) with an average pressure of 95 psi over 16 significantly loaded subpanels. By time step 38 the load has extended over the entire panel but is only 2 subpanels high. The total load is still 181 LT (1.80 MN) at time step 39.

An example of an event that occurred on the side panel is shown in Fig. 23. The bow is again to the left and the smaller numbered waterlines are closer to the ice surface. The event in Fig. 23 occurred on September 2 at 00:49:53. The highest pressure on a single subpanel for this event was 679 psi (4.68 MPa), the second highest recorded on the side panel (the event at 17:14:46 on September 1 recorded a single subpanel pressure of 715 psi (4.93 MPa)). The event shown in Fig. 23 was also the second highest total load on the side panel, 123 LT (1.23 MN). The highest load of 136 LT (1.36 MPa) occurred in the same event that gave the highest single subpanel pressure.

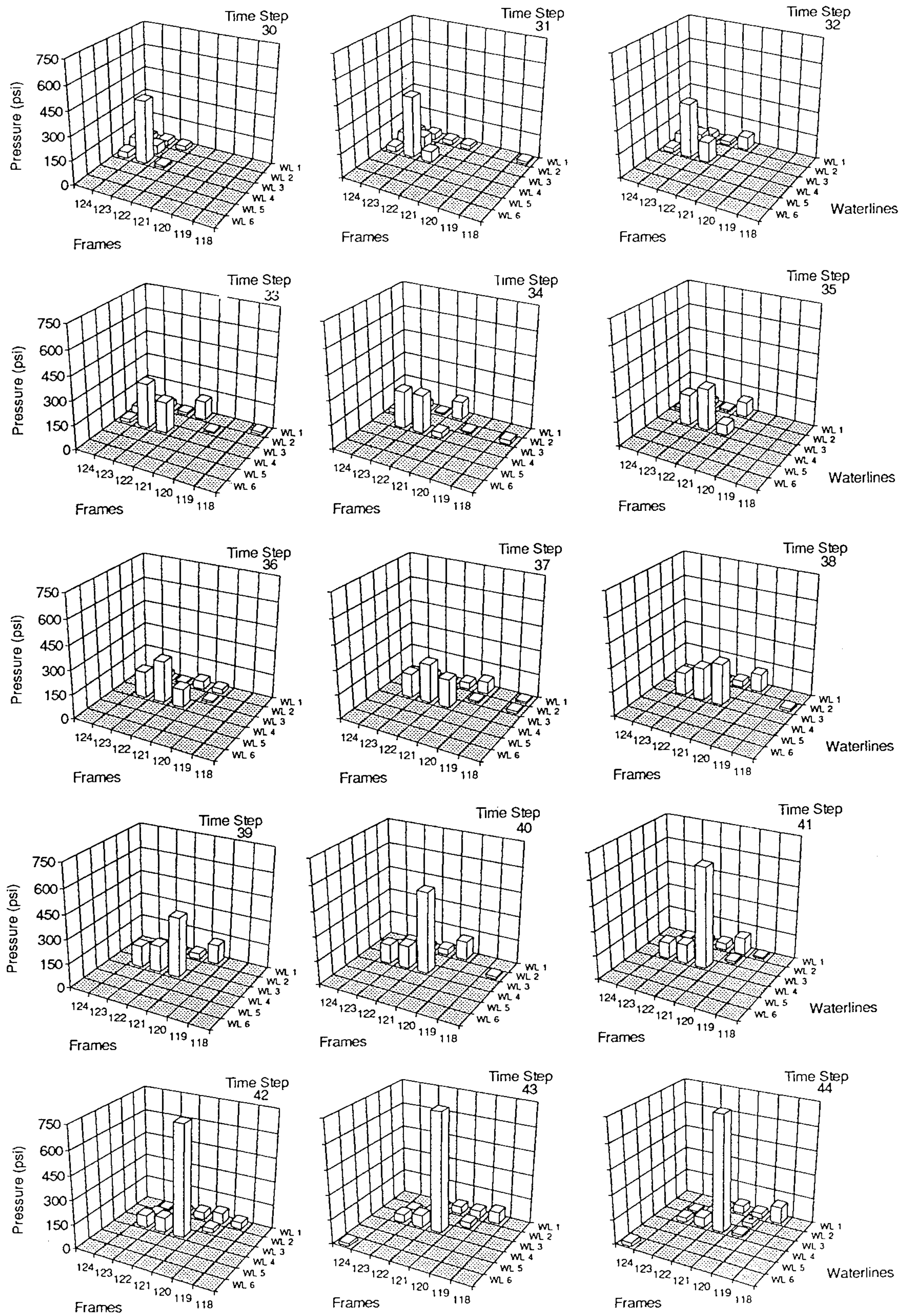


Figure 21. Segment of the pressure time-history for a bow panel event on August 28 at 16:22:45.

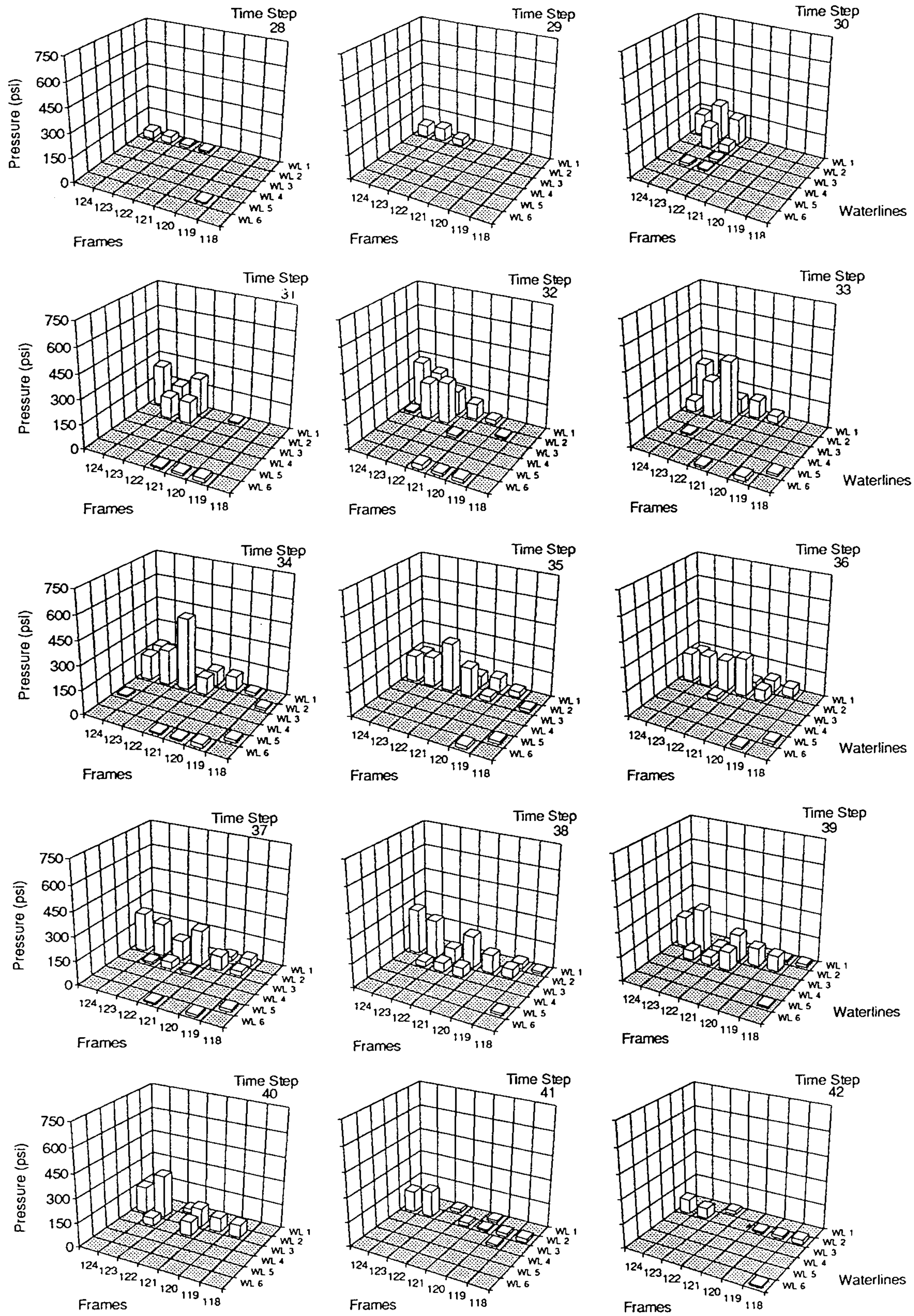


Figure 22. Segment of the pressure time-history for a bow panel event on September 1 at 00:01:03.

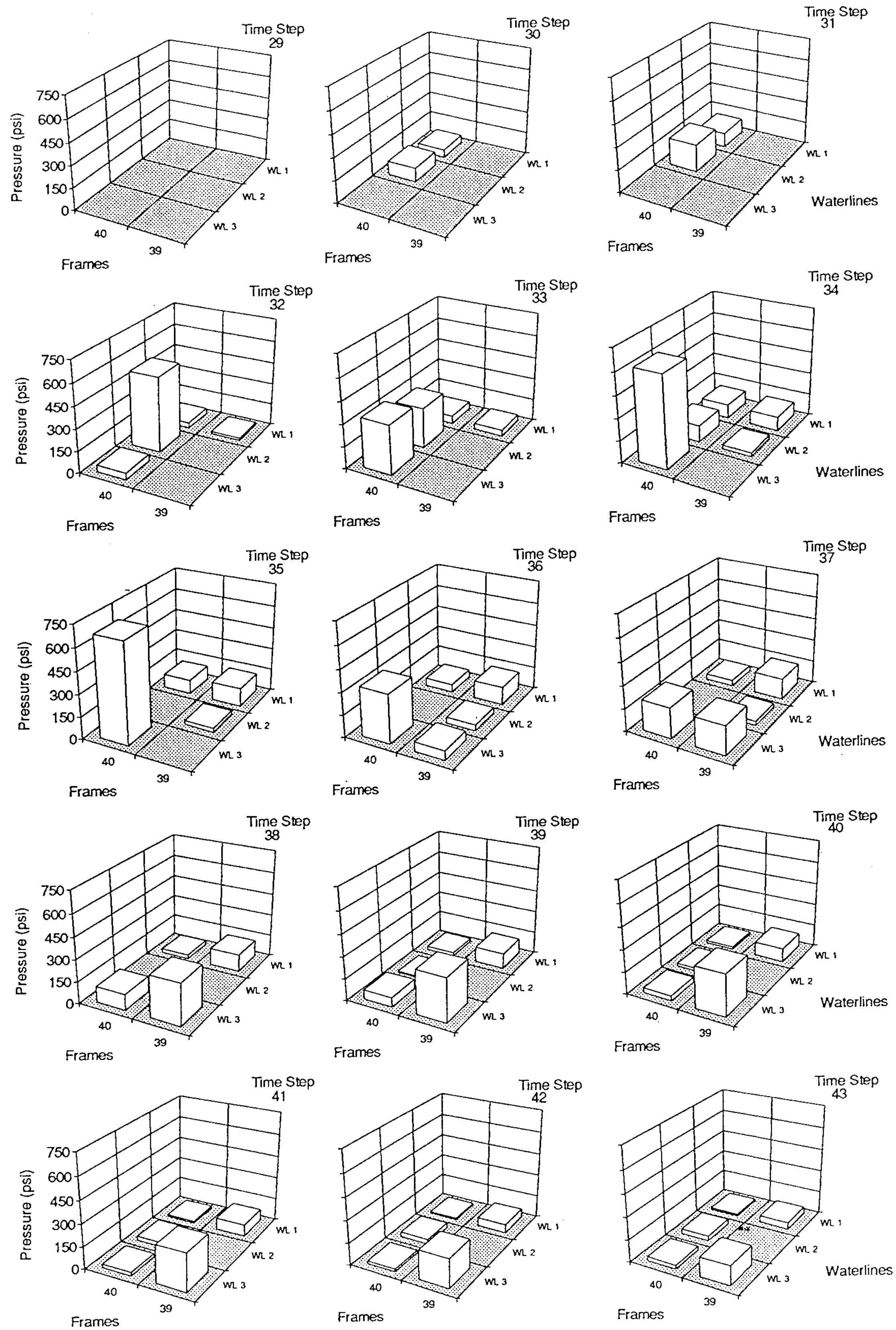


Figure 23. Segment of the pressure time-history for a side panel event on September 2 at 00:49:53.

One of the extreme events that occurred on the transom panel is shown in Fig. 24. Figure 24 is presented as if the viewer is inside the ship looking aft at the panel. The event occurred on September 2 at 06:34:15. It was the event with both the highest recorded single subpanel pressure, 348 psi (2.40 MPa), and total load, 56 LT (.56 MN), on the transom panel.

The highest event that occurred on the bottom panel, both in terms of single subpanel pressure and total load, is shown in Fig. 25. The bow is up and to the right in Fig. 25. The event occurred on September 2 at 10:49:44. The single subpanel pressure was 147 psi (1.01 MPa) and the total load was 51 LT (.51 MN).

The data reduction process generated two types of files, time-histories of each individual impact and a summary file of the significant properties of the impact for all the data. The summary file contains the curves of pressure versus area, pressure versus frame length (height or girth) and pressure versus waterline length (width) for the time of peak pressure and the time of peak force within each impact. The file contains the maximum local load on the panel, and the times and locations of the instantaneous peak pressure on the panel for the time of peak pressure and time of peak force. This file was used extensively to view the data in the different ways with the results presented in this and the following sections. Presented in Table 7 is a summary of the largest three reduced impact events for each of the hull panels both in terms of single subpanel pressure and local load. The bow area shows the number of frames that were active (though not necessarily simultaneously) during the event.

The first analysis determined the peak envelope of pressure versus contact area, length along a frame, and length along a waterline (or perpendicular to the frames). The envelope curve for pressure versus contact area as well as the significant impact events that generated the envelope are shown in Fig. 26 for the bow panel. The envelope curve follows a slope of area to the -1 power over much of its extent; however, most of the individual events have a smaller negative power for several data points at the start of the slope. One must remember that the small areas have many more impacts than the large areas and this effects the shape of the envelope curve. The highest pressure recorded over a single subpanel on the bow was 735 psi (5.07 MPa) during the event on August 28 at 16:22:45. The highest local load measured on the bow panel was 236 LT (2.35 MN) during the event on September 1 at 00:01:03. Similarly, the envelope of pressure versus frame loaded length is shown in Fig. 27 and versus waterline loaded length is shown in Fig. 28. These are plotted as load per unit length versus length based on a frame spacing of 20.8 in. (528 mm) and a gage spacing of 16 in. (406 mm), respectively. The highest frame load, 109.2 LT (1.09 MN), was recorded

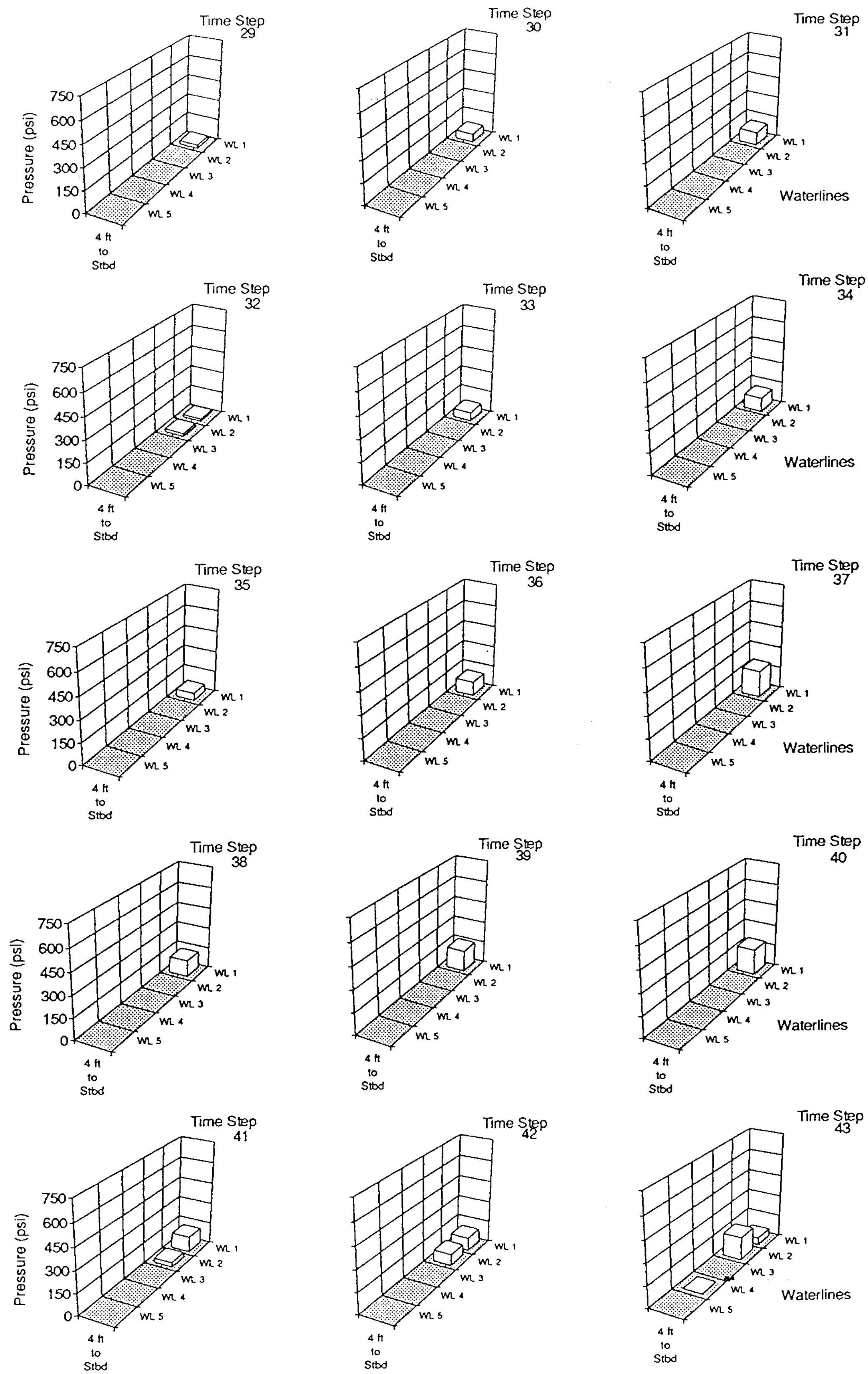


Figure 24. Segment of the pressure time-history for a transom panel event on September 2 at 06:34:15.

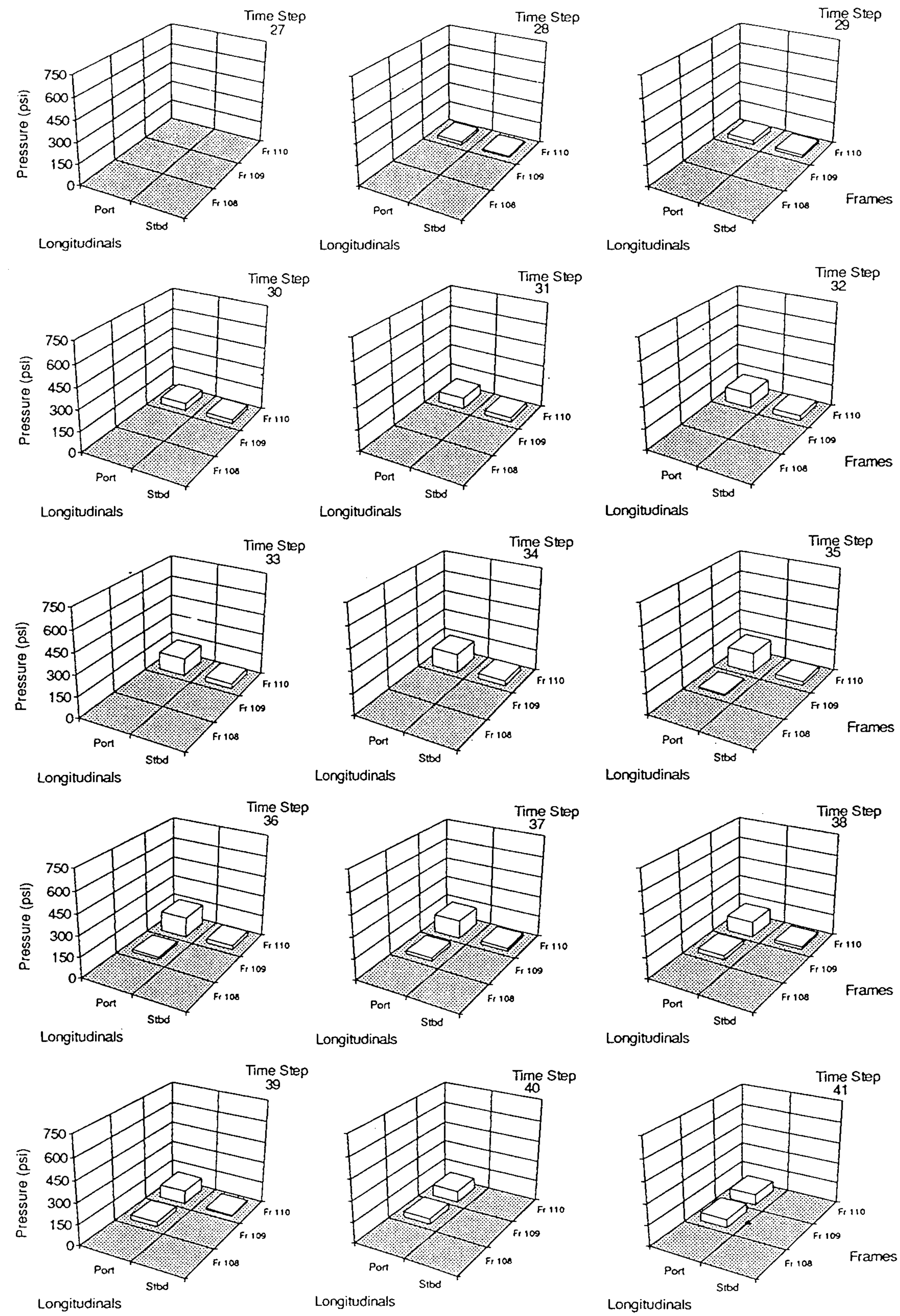


Figure 25. Segment of the pressure time-history for a bottom panel event on September 2 at 10:49:44.

Table 7. Summary of Largest Reduced Impact Events for Each Panel

Event No.	Record No.	Time GMT	Date	Panel Location	No. Bow Frames	Max Press. (psi)	Max Force (LT)	Comments
Largest Events Sorted by Single Subpanel Pressure								
5	4	16:22:45	28 Aug 92	Bow	7	735	178	Excellent
307	308	23:58:36	31 Aug 92	Bow	7	619	198	Excellent, 2 peaks
138	142	19:06:52	30 Aug 92	Bow	3	588	123	Excellent, 16 Chn active
405	391	17:14:46	1 Sep 92	Side		715	136	Excellent
538	503	0:49:53	2 Sep 92	Side		679	123	Excellent
395	383	16:53:55	1 Sep 92	Side		667	86	Excellent, 2 peaks
631	582	10:49:44	2 Sep 92	Bottom		147	51	Excellent
524	494	23:24:33	1 Sep 92	Bottom		89	32	Excellent
297	299	23:29:44	31 Aug 92	Bottom		82	47	Good
604	557	6:34:15	2 Sep 92	Transom		348	56	Excel., Backing, Milling
280	277	21:57:08	31 Aug 92	Transom		256	41	Excel., Spike Removed
336	331	1:15:30	1 Sep 92	Transom		256	41	Excellent, 2 peaks
Largest Events Sorted by Local Load								
308	309	0:01:03	1 Sep 92	Bow	7	453	236	Excellent
307	308	23:58:36	31 Aug 92	Bow	7	619	198	Excellent, 2 peaks
344	338	1:38:24	1 Sep 92	Bow	7	270	179	Long event, 2 peaks
405	391	17:14:46	1 Sep 92	Side		715	136	Excellent
538	503	0:49:53	2 Sep 92	Side		679	123	Excellent
363	357	14:54:52	1 Sep 92	Side		496	123	Excellent
631	582	10:49:44	2 Sep 92	Bottom		147	51	Excellent
297	299	23:29:44	31 Aug 92	Bottom		82	47	Good
524	494	23:24:33	1 Sep 92	Bottom		89	32	Excellent
604	557	6:34:15	2 Sep 92	Transom		348	56	Excel., Backing, Milling
280	277	21:57:08	31 Aug 92	Transom		256	41	Excel., Spike Removed
336	331	1:15:30	1 Sep 92	Transom		256	41	Excellent, 2 peaks

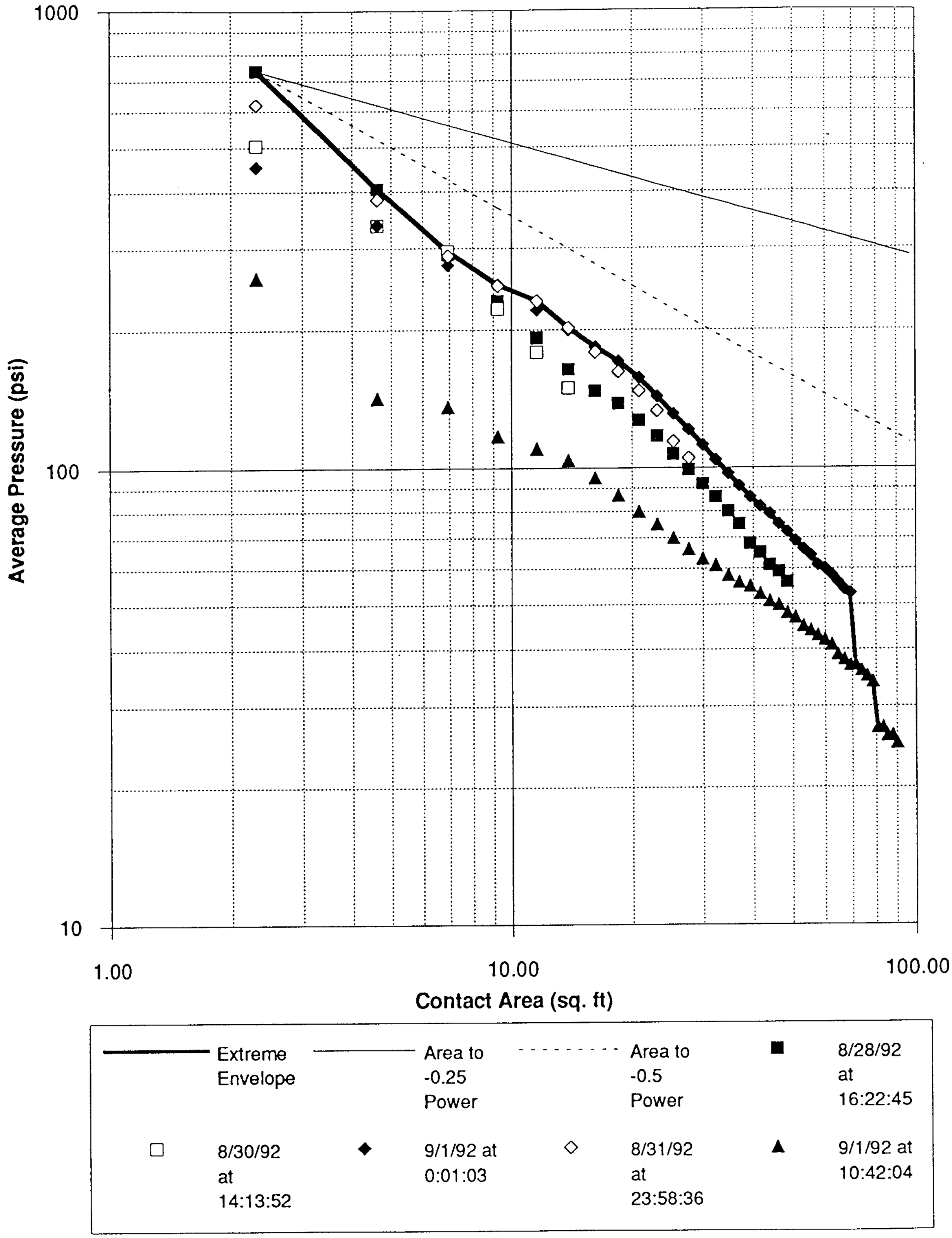


Figure 26. Bow panel extreme pressure envelope versus contact area.

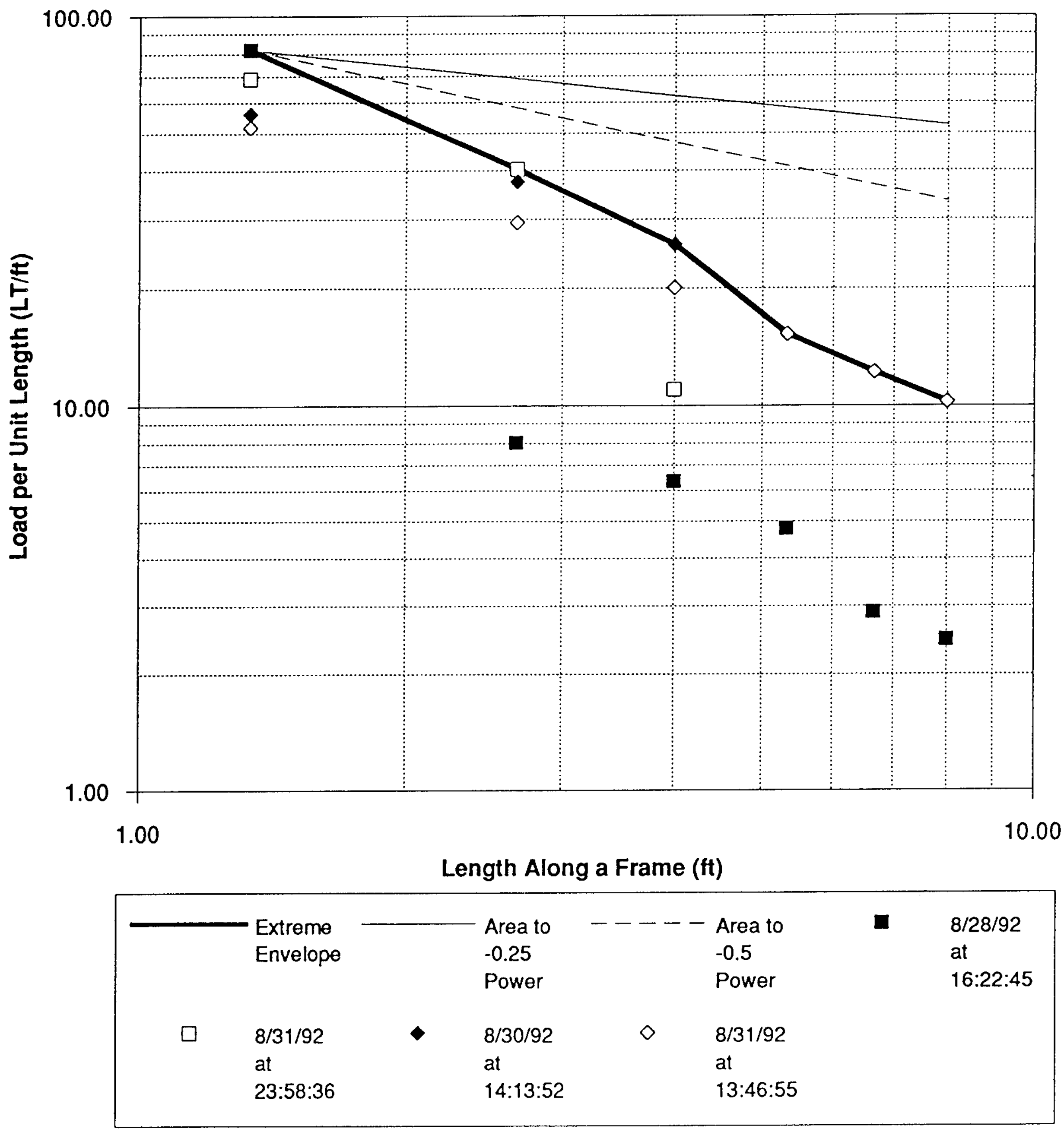


Figure 27. Bow panel extreme load per unit length envelope versus frame length.

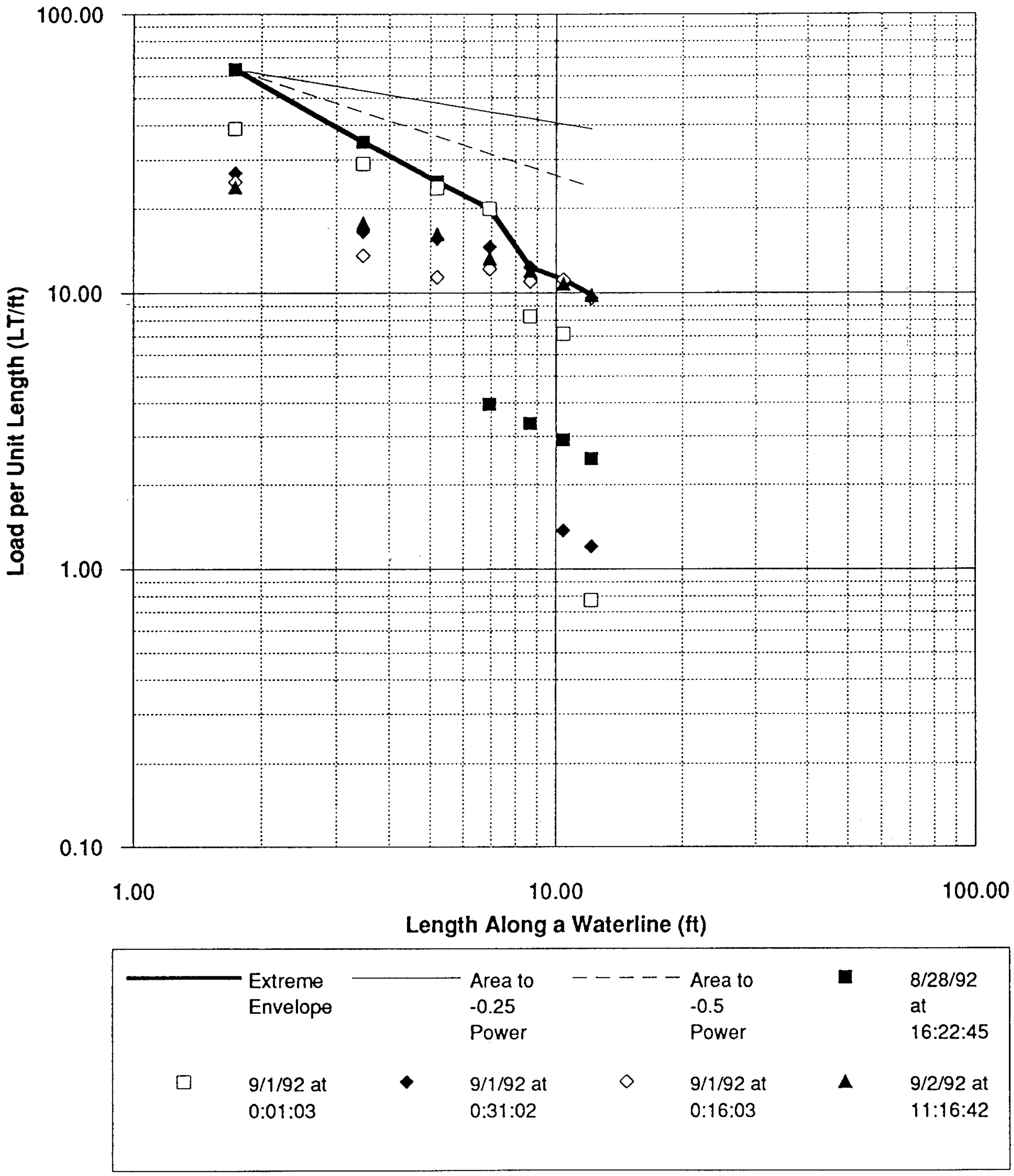


Figure 28. Bow panel extreme load per unit length envelope versus waterline length.

during the event on August 28 at 16:22:45. The highest load along a waterline was recorded on September 1 at 00:01:03. It was 138.5 LT (1.38 MN).

A similar set of plots are presented for the side hull panel envelope of peak pressure versus contact area, length along a frame, and length along a waterline in Figs. 29, 30, and 31. Noted on each figure are the significant impacts events that comprise the envelope curve. In the first figure (Fig. 29) the envelope curve follows a slope of area to the -0.5 power initially, then the slope falls off to a line of constant force (a constant value for pressure divided by area gives a slope of -1). The highest pressure recorded over a single subpanel on the side was 715 psi (4.93 MPa) during the event on September 1 at 17:14:46. This is almost the same magnitude as the greatest measured bow panel single subpanel pressure. The highest local load measured on the side panel was 136 LT (1.36 MN) and occurred during the same event. As before, plots of the envelope of pressure versus frame length and versus waterline loaded length were developed and are shown as Figs. 30 and 31. These are based on a frame spacing of 24 in. (610 mm) and a gage spacing of 12 in. (305 mm). The highest frame load was 136.0 LT (1.36 MN), and was recorded during the event on September 1 at 17:14:46. It is significant to note that this side panel frame load is higher than the highest bow panel frame load of 109.2 LT (1.09 MN). The highest load along a waterline was recorded on September 2 at 00:49:53 and was 112.1 LT (1.12 MN) in magnitude.

Envelope plots for the bottom panel are presented in Figs. 32, 33, and 34. The highest single subpanel pressure (147 psi, 1.01 MPa) and highest local load (51 LT, 0.50 MN) measured on the bottom panel both occurred during the event on September 2 at 10:49:44. Because the panel is located on the vessel's bottom, panel orientation does not carry the same significance as it does for the other hull panels. The floors making up the bottom panel frames are oriented athwartship. The highest frame load (athwartship subpanels) and load perpendicular to the frames (longitudinal subpanels) also occurred during this event. They measured 45.0 LT (0.45 MN) and 3.49 LT (0.42 MN), respectively. The frame spacing and gage spacing for the bottom panel are almost the same, 24 in. (610 mm) and 23.6 in. (599 mm), respectively. For both the frame load and load perpendicular to the frames the maximum loaded length was imposed and was two subpanels or 4 ft (1.2 m).

A single event proved to be predominant in the case of the transom panel also. This event occurred on September 2 at 06:34:15 and generated a maximum single subpanel pressure of 348 psi (2.40 MPa) and highest local load of 56 LT (0.56 MN). The envelope plots for the transom panel are presented in Figs. 35 and 36. The highest frame load was 55.9 LT

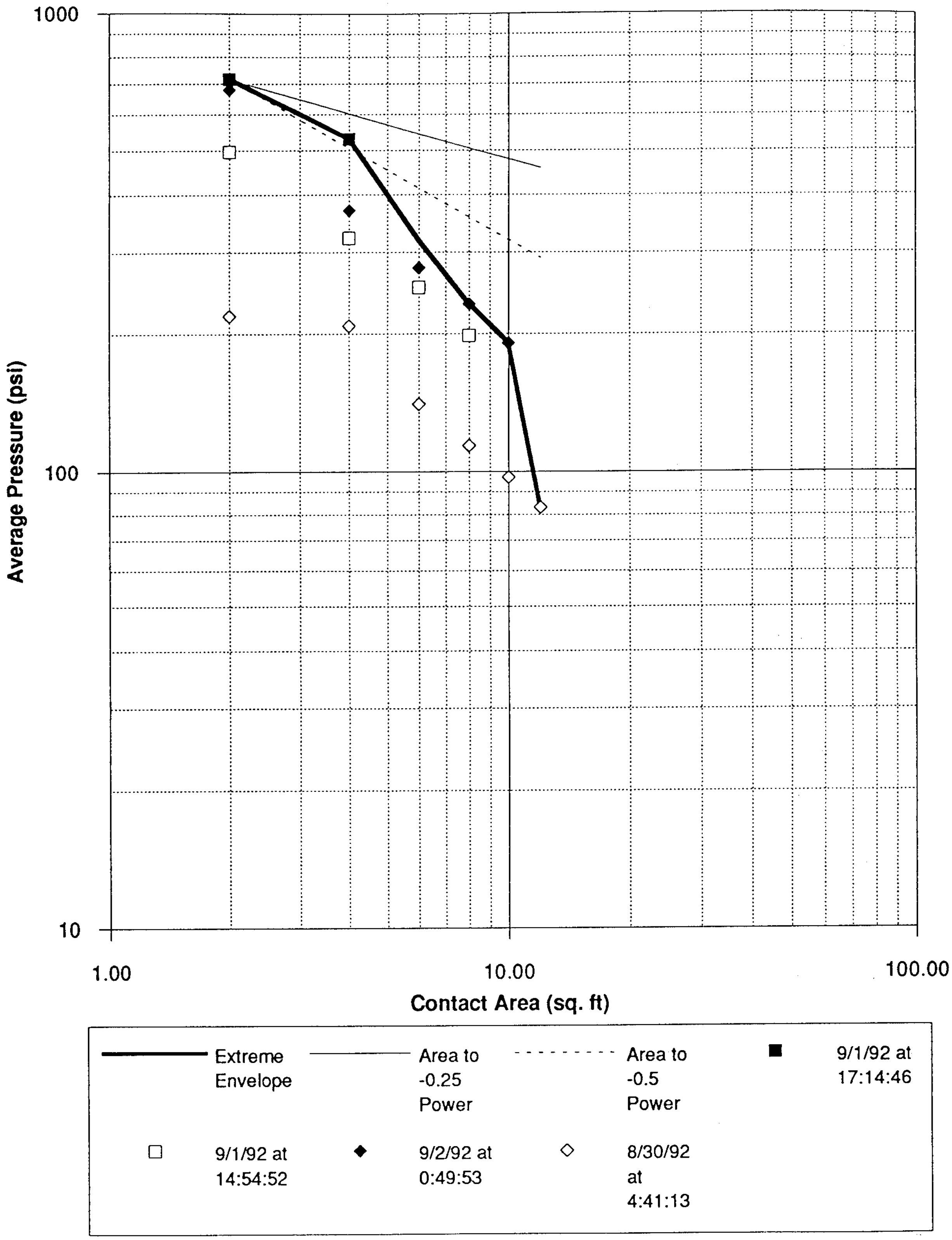


Figure 29. Side panel extreme pressure envelope versus contact area.

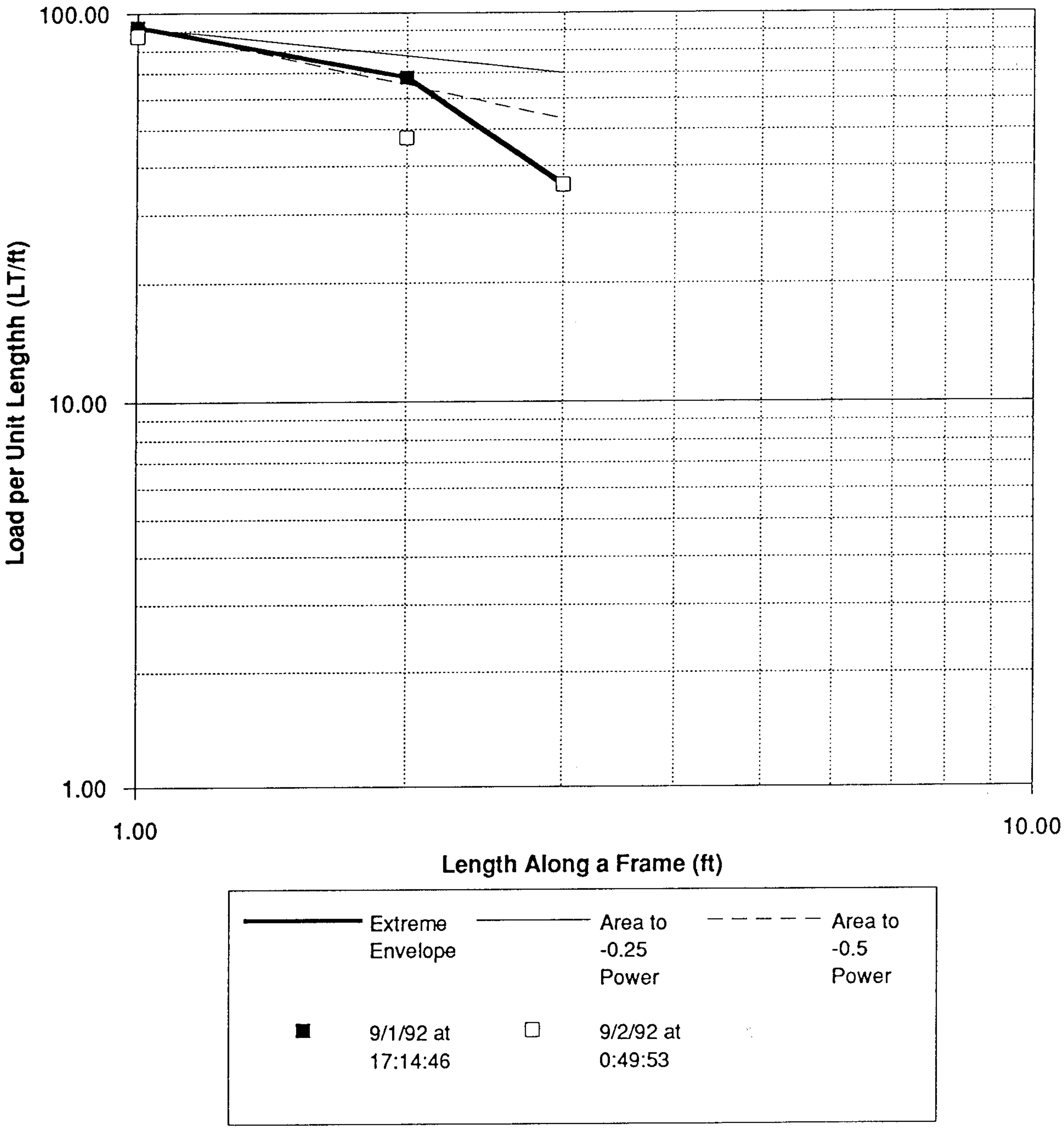


Figure 30. Side panel extreme load per unit length envelope versus frame length.

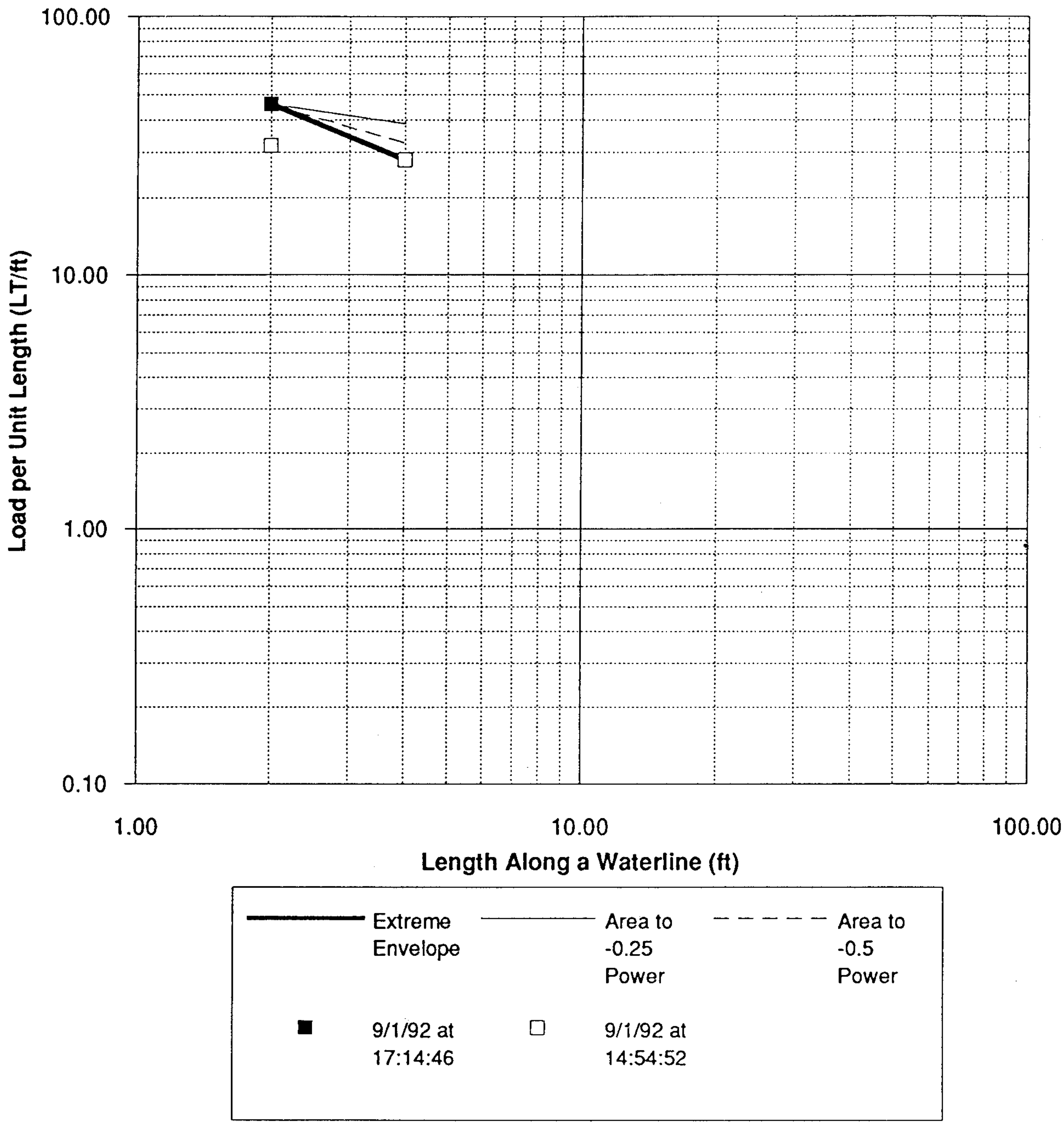


Figure 31. Side panel extreme load per unit length envelope versus waterline length.

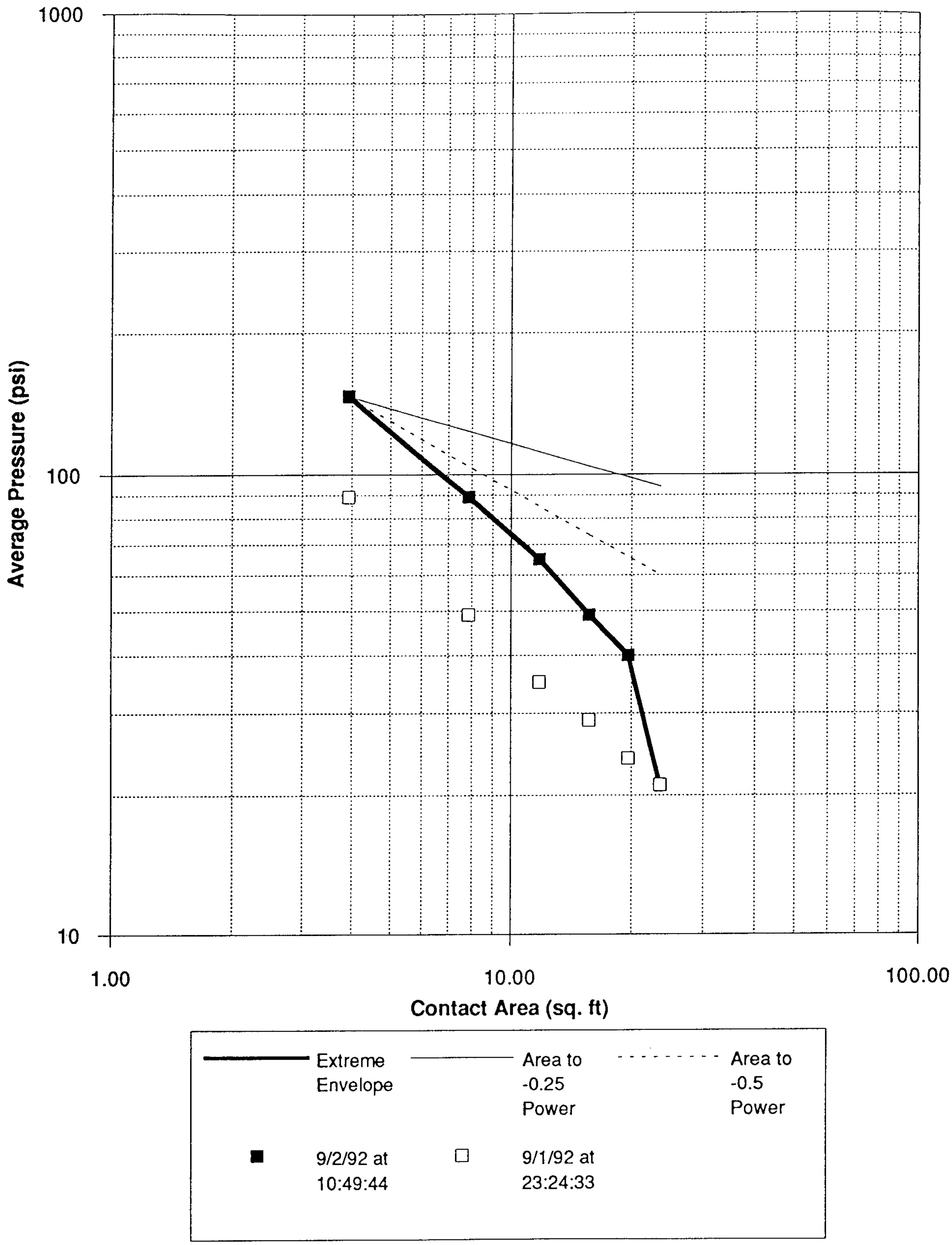


Figure 32. Bottom panel extreme pressure envelope versus contact area.

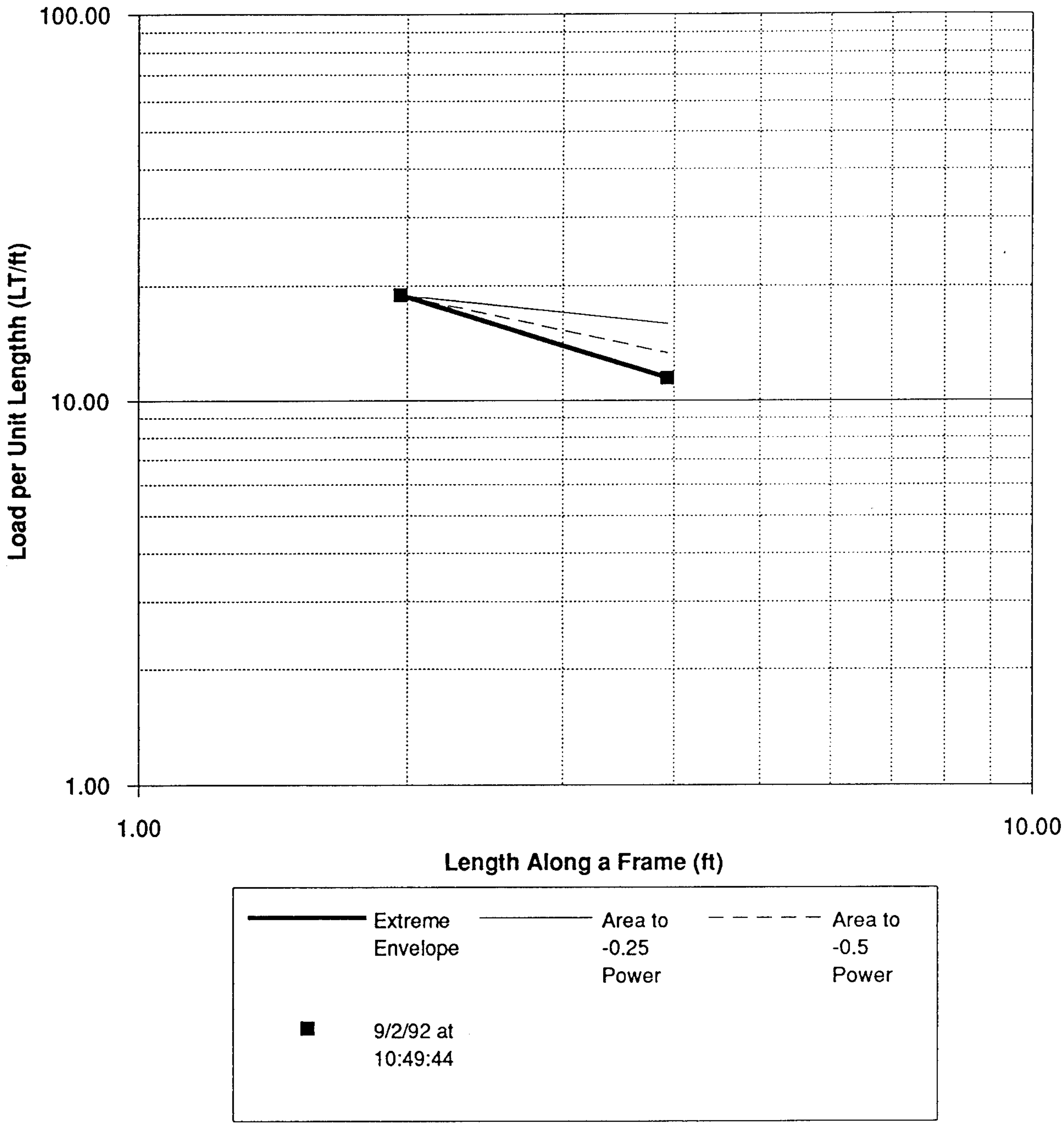


Figure 33. Bottom panel extreme load per unit length envelope versus frame length.

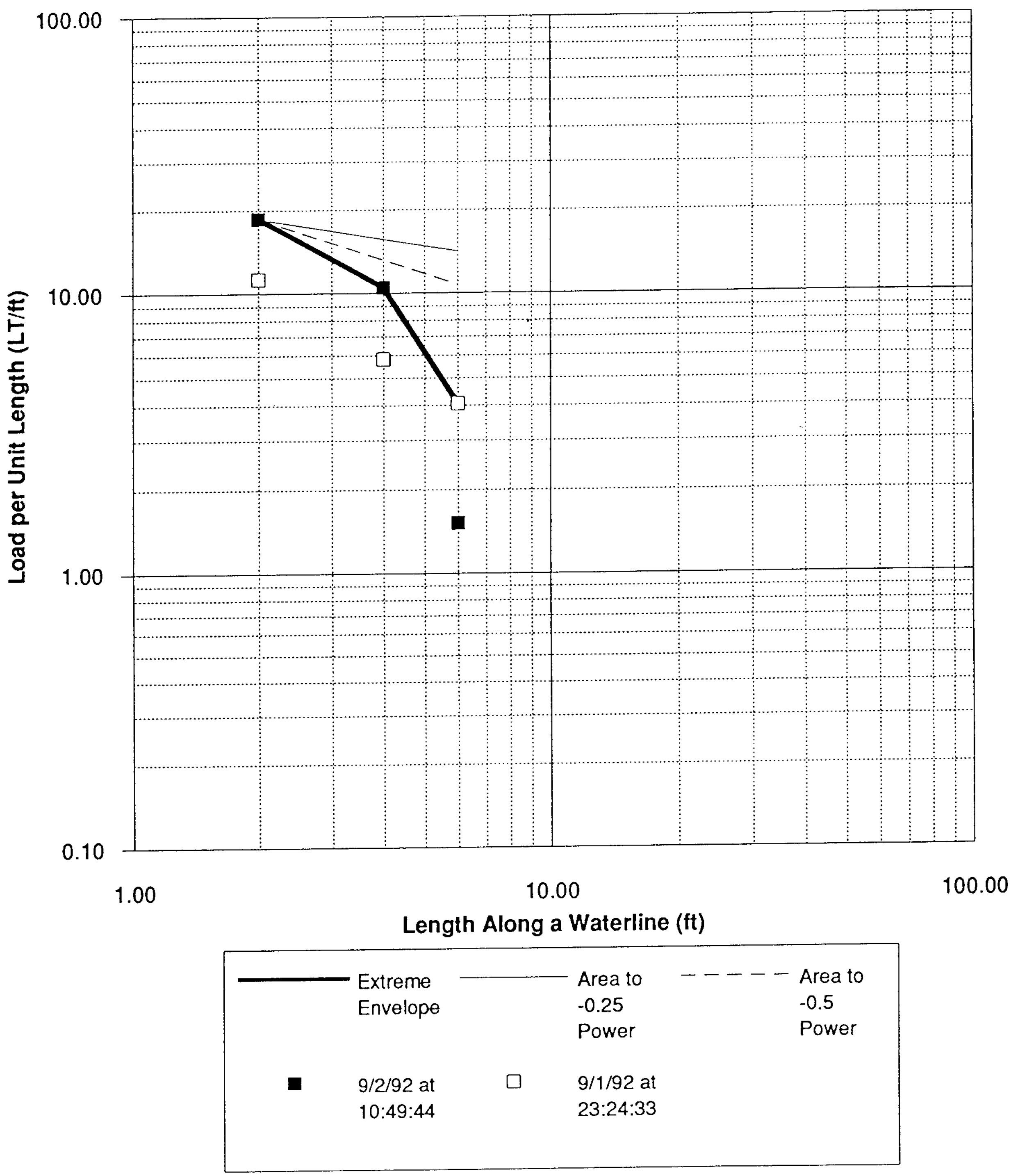


Figure 34. Bottom panel extreme load per unit length envelope versus longitudinal length.

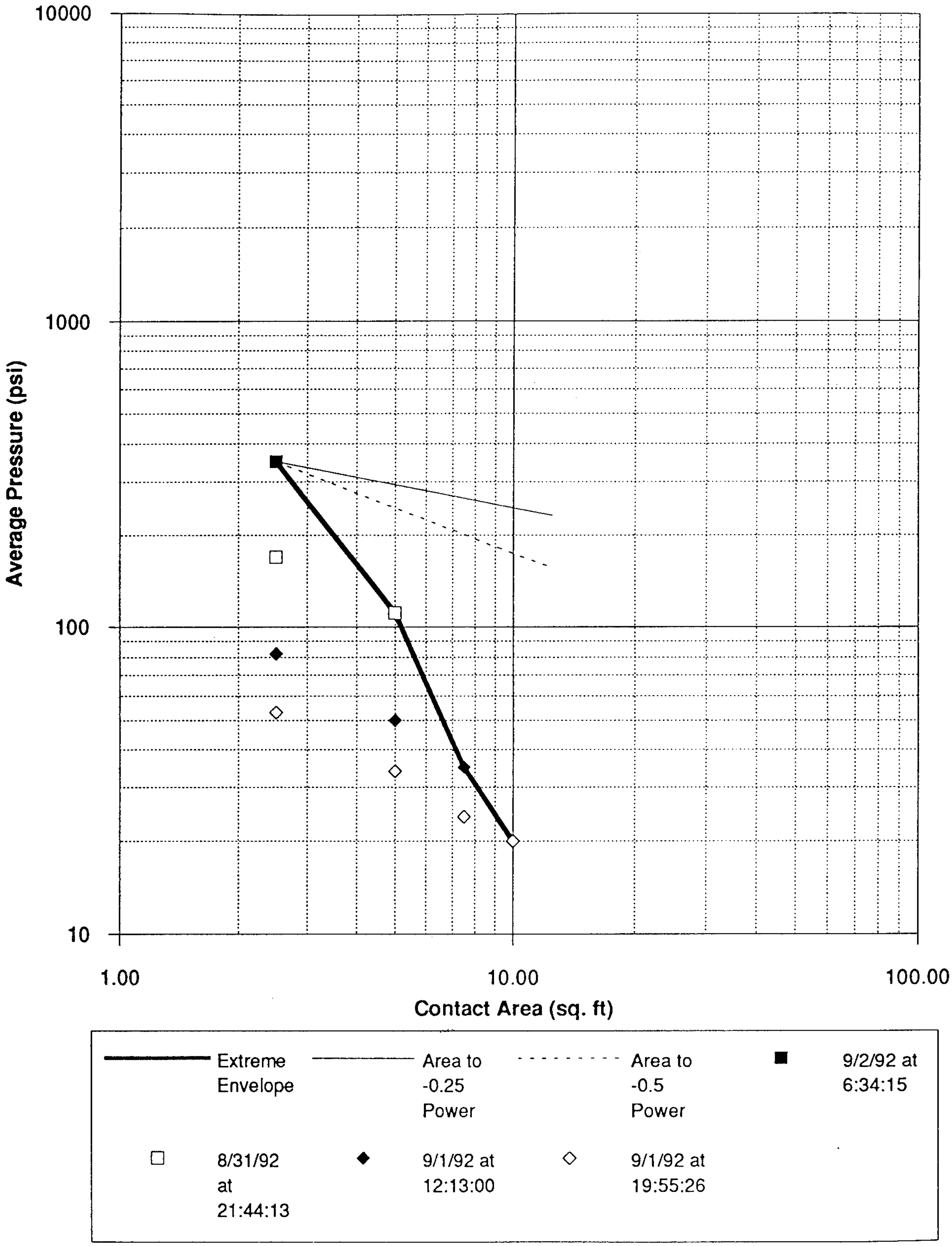


Figure 35. Transom panel extreme pressure envelope versus contact area.

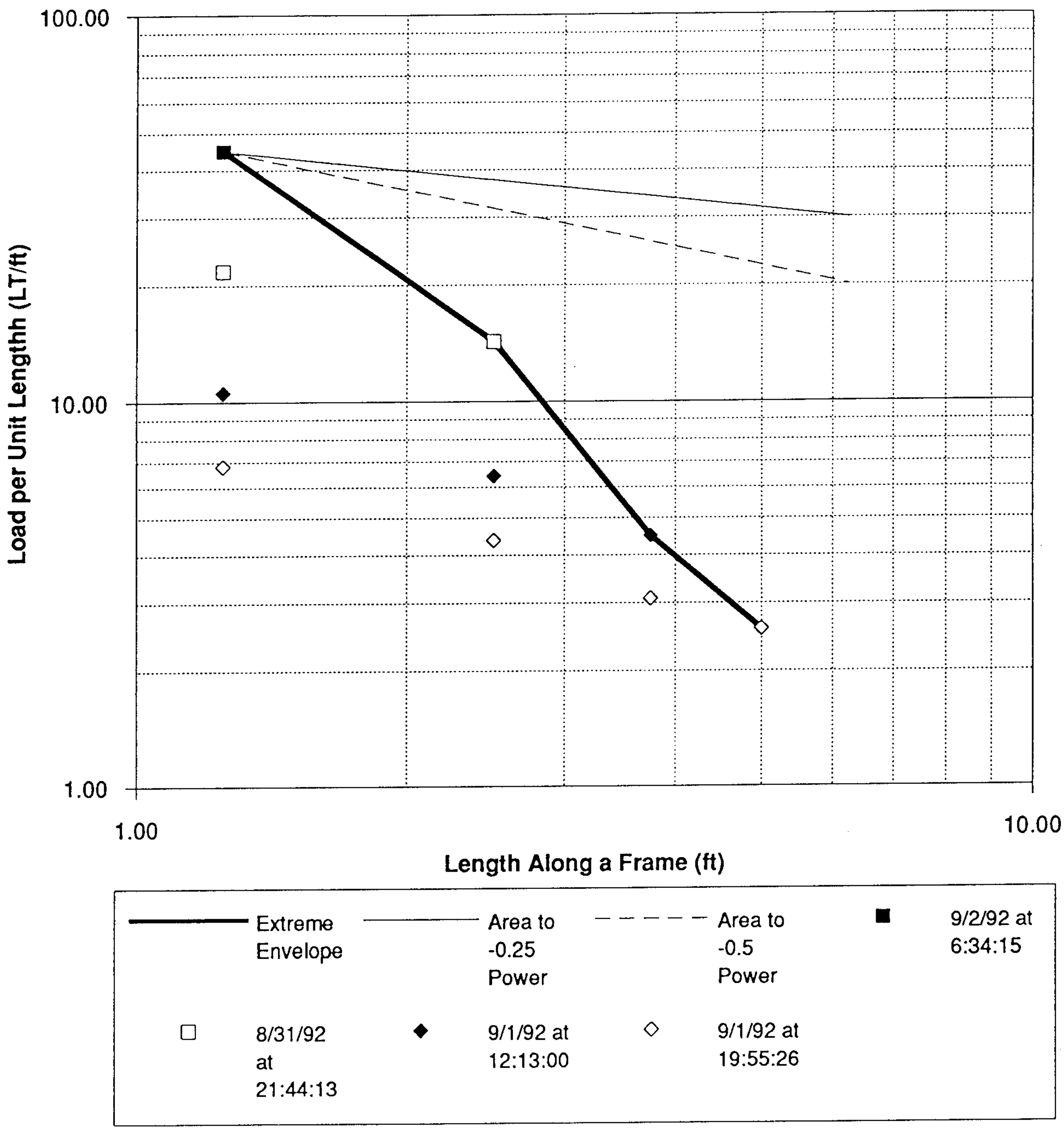


Figure 36. Transom panel extreme load per unit length envelope versus frame length.

(0.56 MN) based on a frame spacing of 24 in. (610 mm) and gage spacing of 15 in. (381 mm). Since only one frame was instrumented in the transom, the highest load per unit length versus waterline length comes directly from the highest single subpanel pressure and is 26.96 LT/ft (0.91 MN/m) for a waterline load of 55.9 LT (0.56 MN).

6.2 THE TRENDS WITH SHIP SPEED AND ICE THICKNESS

Throughout the time *Nathaniel B. Palmer* was in the pack ice, a bridge watch was manned 24 hr a day to observe ice conditions, ship operations, and weather conditions. Observed data were collected, checked and entered into an EXCEL spreadsheet. The resulting spreadsheet was combined with the summary file of the pressure and loads data and the ship speed computed from GPS files for a comparison of the loads and pressure with the ice conditions and speed (see Appendix E).

Ship speed was obtained by the noting the distance and time between successive GPS fixes (1 sec samples) and computing the speed over the ground. Ship impact speed was the average of the GPS fixes over the impact internal of 5 sec for all events. The procedure worked well except when insufficient satellites were available for the GPS to acquire the ship's location. The peak pressures for a single subpanel from all of the hull panels are shown plotted against the ship speed in Fig. 37. The total local load measured from all subpanels of a hull panel are shown in Fig. 38. There are a total of 420 data points where GPS speed data were obtainable. It should be noted that the single subpanel or measurement areas are different for each panel and the size of the subpanel influences the measured pressure to some extent. No adjustment has been made for differences in subpanel area in Fig. 37. In addition, the panels must be large enough to capture the entire contact area to compare the total local load from one panel to another. The envelope curves of Figs. 26, 29, 32, and 35 indicate that most of the extreme event approach a line of constant force (45° on the log-log plot of pressure versus area) for all but the highest side load and the loads on the transom.

In the case of single subpanel pressure versus speed (Fig. 37) both the bow and side panels have the highest pressures at the relatively low speed of 2 to 6 kt. Also, the distribution of the pressures measured on the side panel with respect to both speed and magnitude follows the distribution of pressures measured on the bow panel except for the higher speeds above 7 kt. For local load versus speed (Fig. 38) the highest load for the bow panel occurs between 5 and 8 kt while the local load on the side panel has a slight trend for a

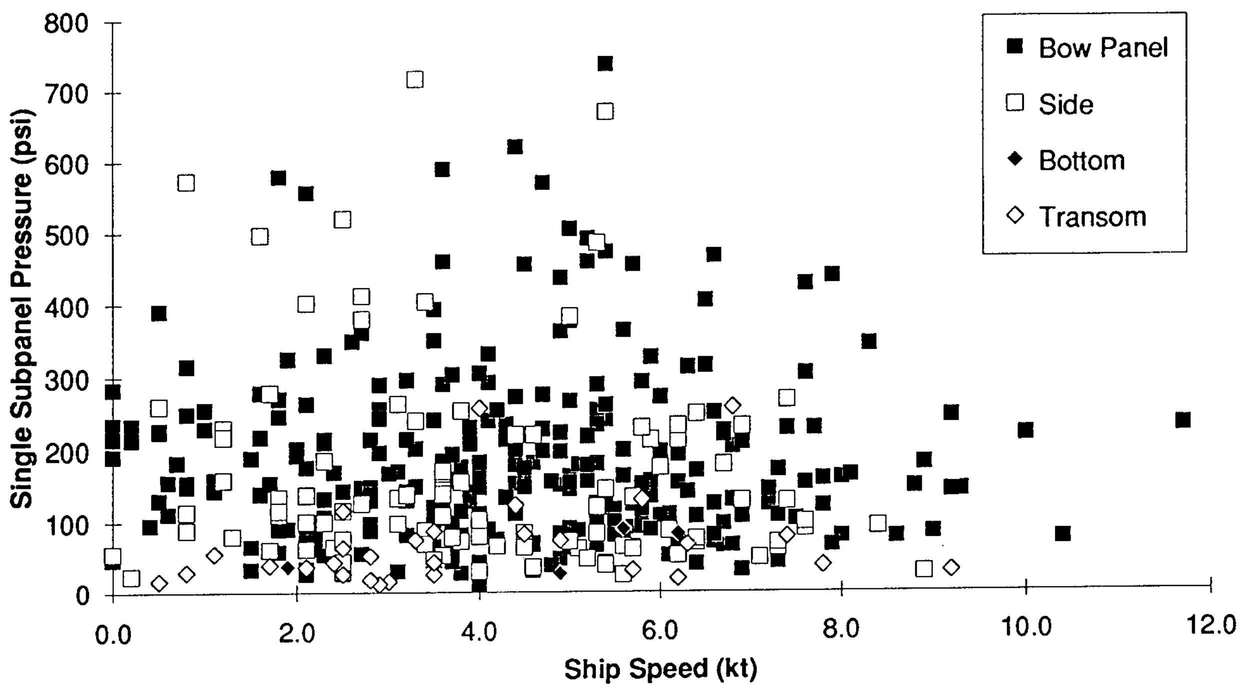


Figure 37. Single subpanel pressure versus ship speed.

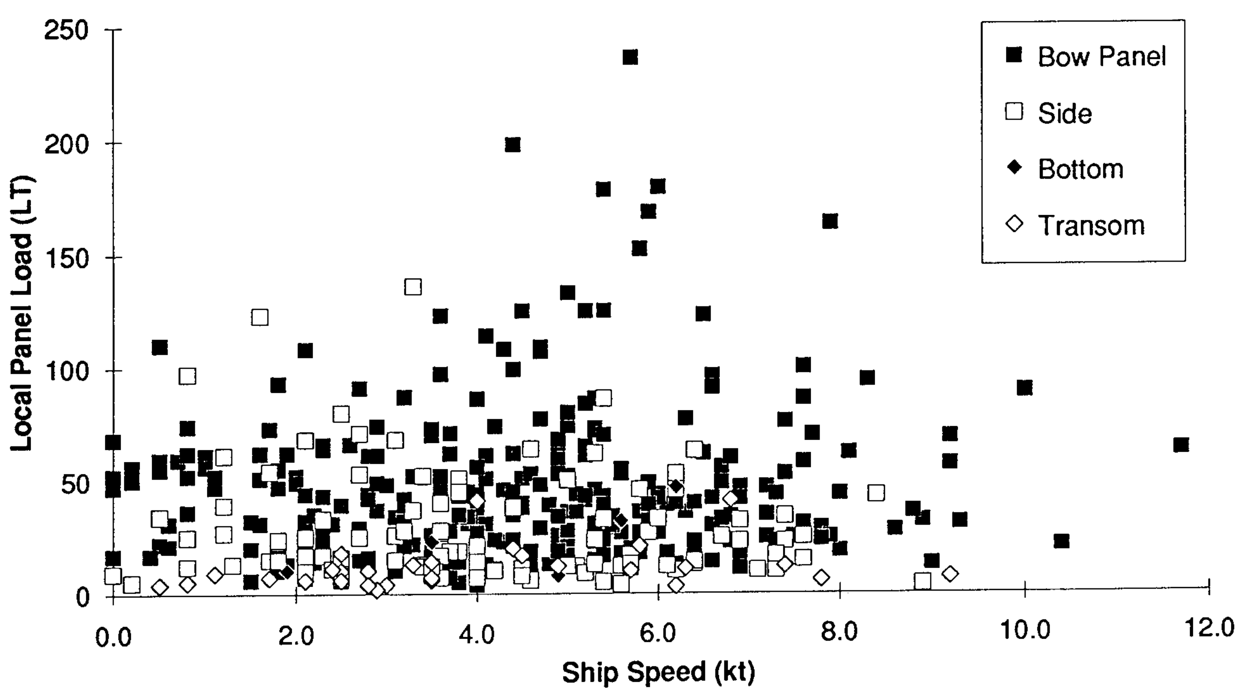


Figure 38. Hull panel local load versus ship speed.

peak near 4 kt. Peaks in these data are presumed to be attributable to the fact that this was the ship speed range for heavier ice conditions and also the most common speed range. Many more events were recorded at lower speeds than at the higher, more typical open water speeds.

Both the average and maximum observed ice thicknesses were recorded and correlated for 332 impact events. These are plotted against the single subpanel pressures in Figs. 39 and 40 for each of the hull panels. The data for each hull panel are displaced slightly from the recorded even foot measurements for ice thickness for clarity in the figures. No particular trend is seen in the peak pressures versus ice thickness. There is an increase in the highest pressures with ice thickness from 2.0 to 3.5 ft, but the highest pressures seem to occur at the thicknesses that were most commonly encountered.

An analysis of force versus ice thickness was also conducted. The total load summed over all subpanels was plotted against the average and maximum observed ice thickness in Figs. 41 and 42 for all of the hull panels. As with the single subpanel pressures, the greatest local load tends to occur at the most frequently encountered ice thickness.

6.3 EXTREME VALUE STATISTICS

The pressures and force encountered during ship-ice impacts are random and follow log-normal type probability distributions. The highest single subpanel pressures for each event were rank ordered and their frequency versus pressure magnitude were computed. The results are shown in Fig. 43 for each panel location.

The extremes of these data can also be examined. The probability of exceeding a particular pressure value associated with the ranked data of Fig. 43 was computed by dividing the ranking by one plus the number of events and subtracting this number from one. The single subpanel pressures for the bow seem to fit a Gumbel type extreme value distribution very well, as shown in Fig. 44.

The data associated with the highest average pressure over two, five, or any number of adjacent subpanels for each event can be analyzed in the same way. Results for a range of increasing areas (greater number of subpanels) are shown in Fig. 45. The linear nature of the Gumbel distribution is preserved even at larger areas, as shown in Fig. 45. The extreme value distributions for the other areas do not exhibit as consistent a trend. The single subpanel pressures for each panel location are shown in Fig. 46. The side and transom panels both

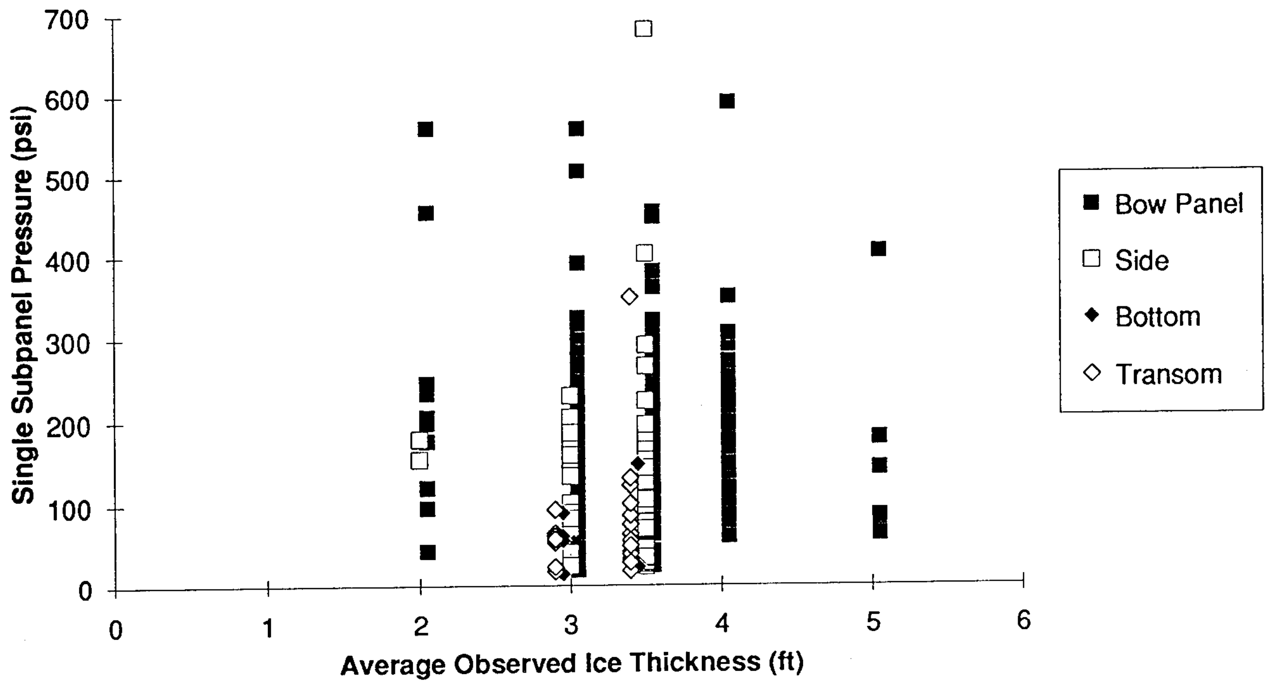


Figure 39. Single subpanel pressure versus average ice thickness.

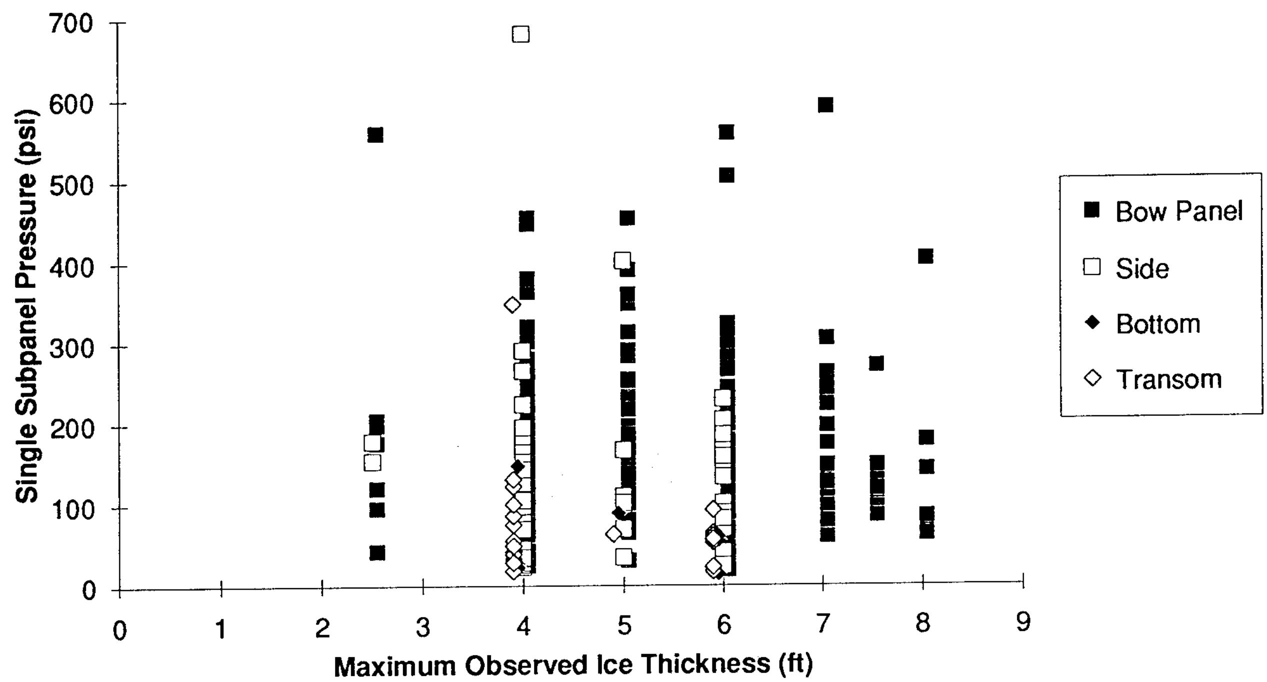


Figure 40. Single subpanel pressure versus maximum ice thickness.

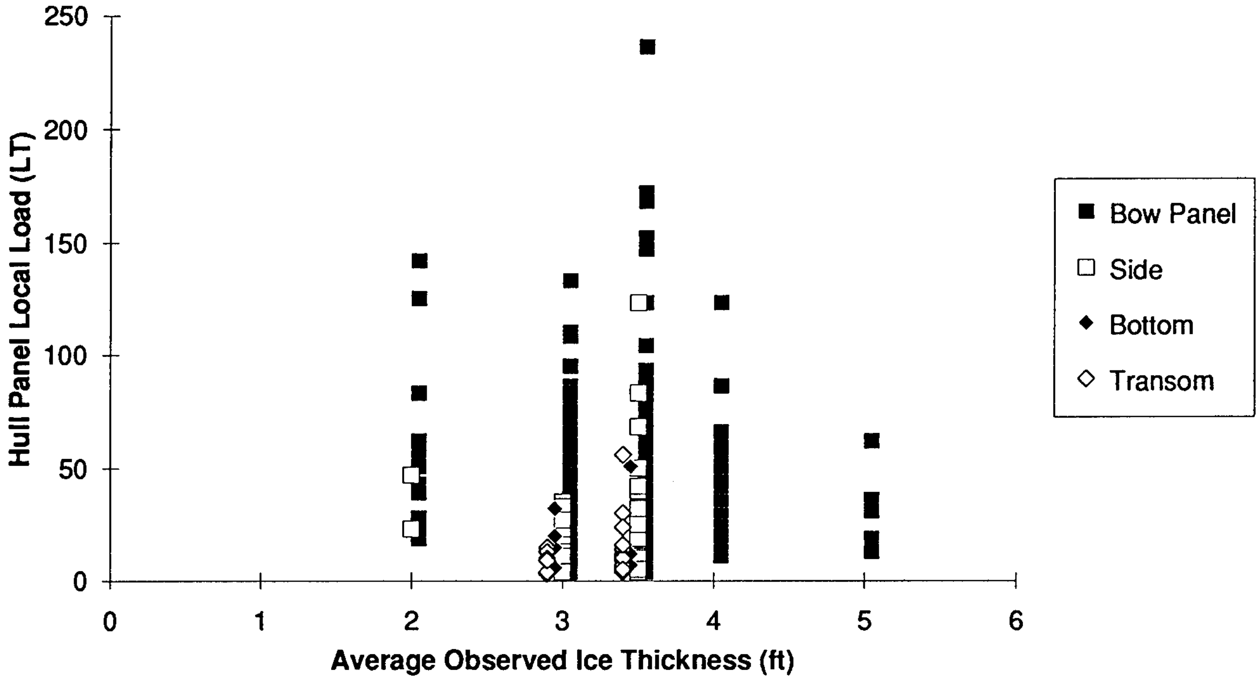


Figure 41. Hull panel local load versus average observed ice thickness.

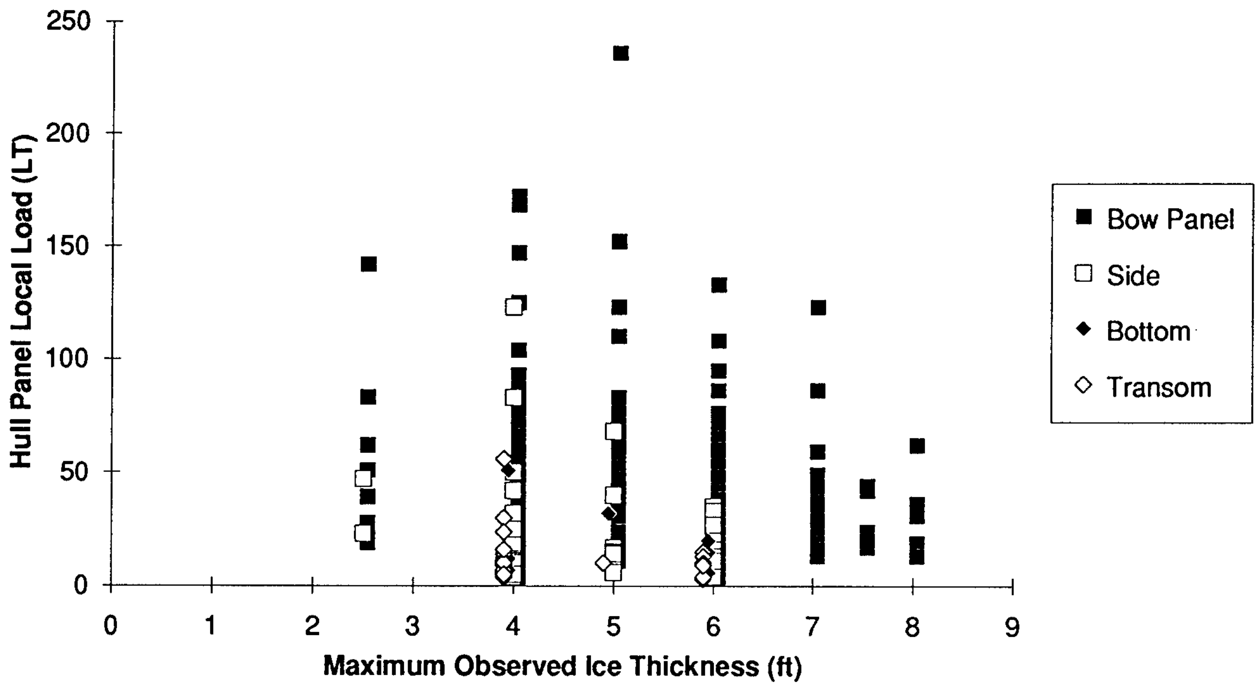


Figure 42. Hull panel local load versus maximum observed ice thickness.

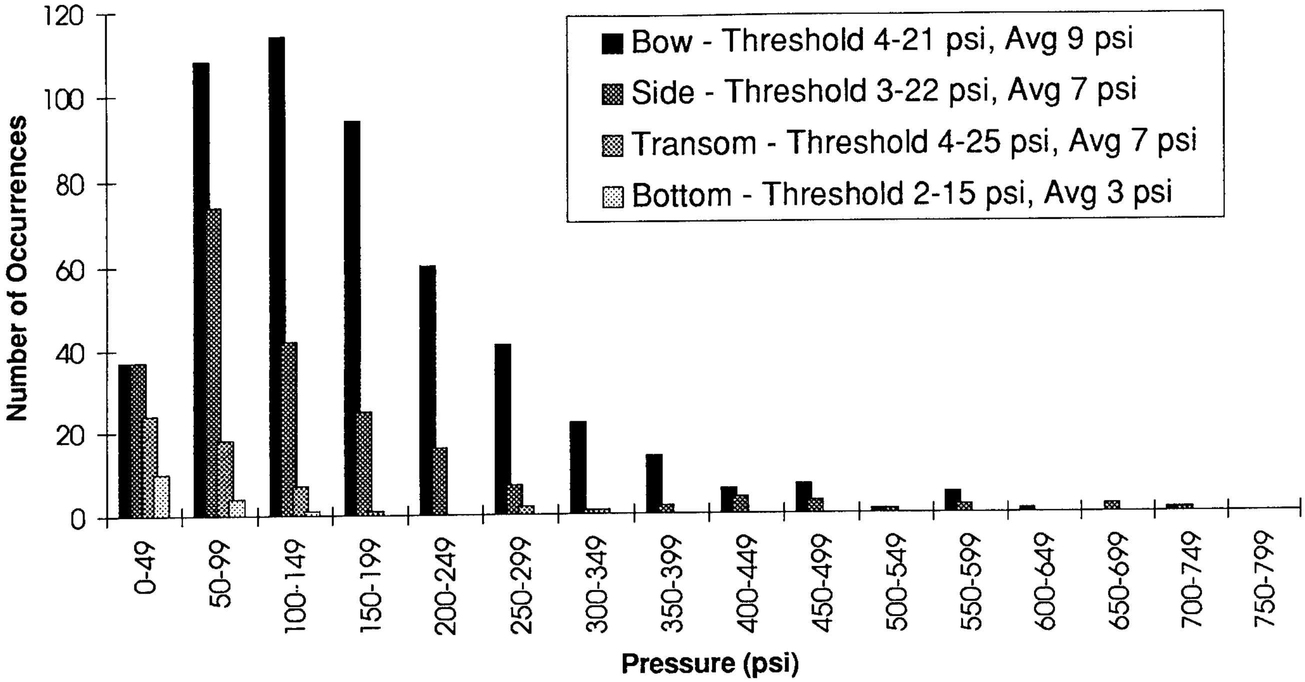


Figure 43. Frequency plot of single subpanel pressures for each panel location.

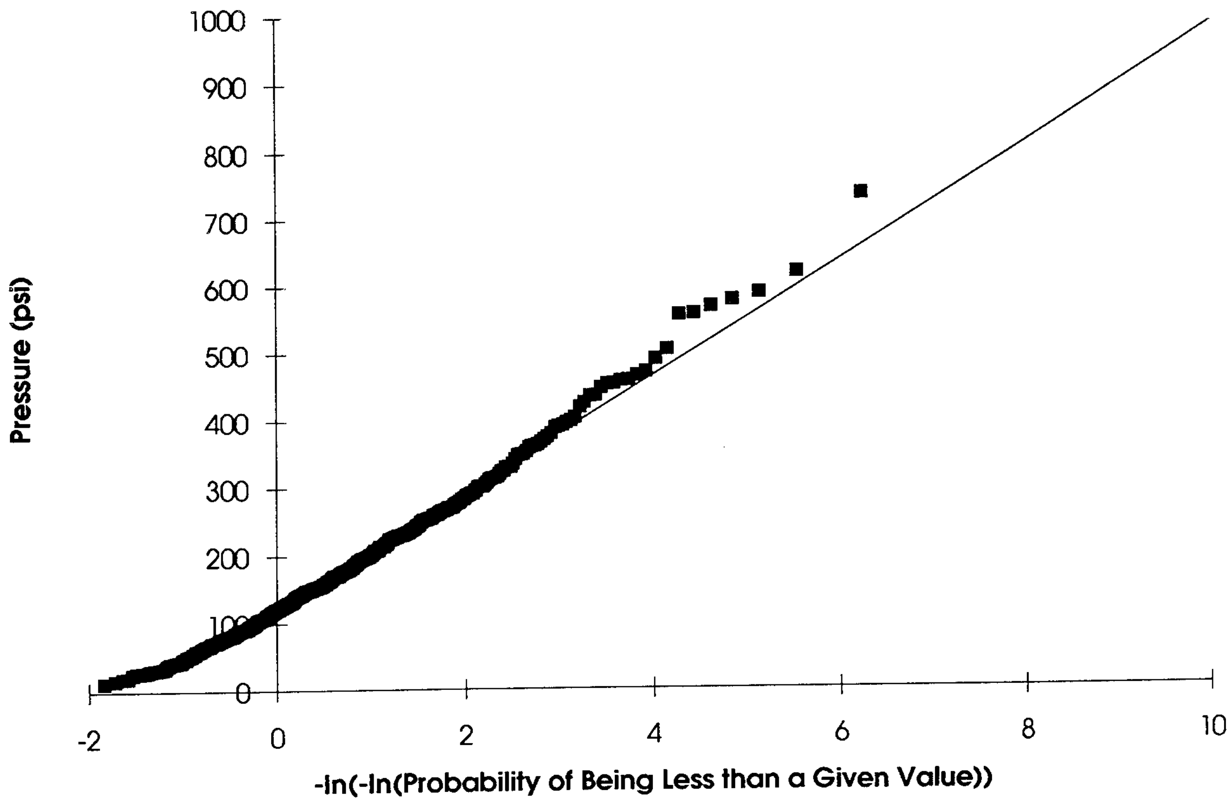


Figure 44. Extreme value distribution of single subpanel pressures for the bow panel.

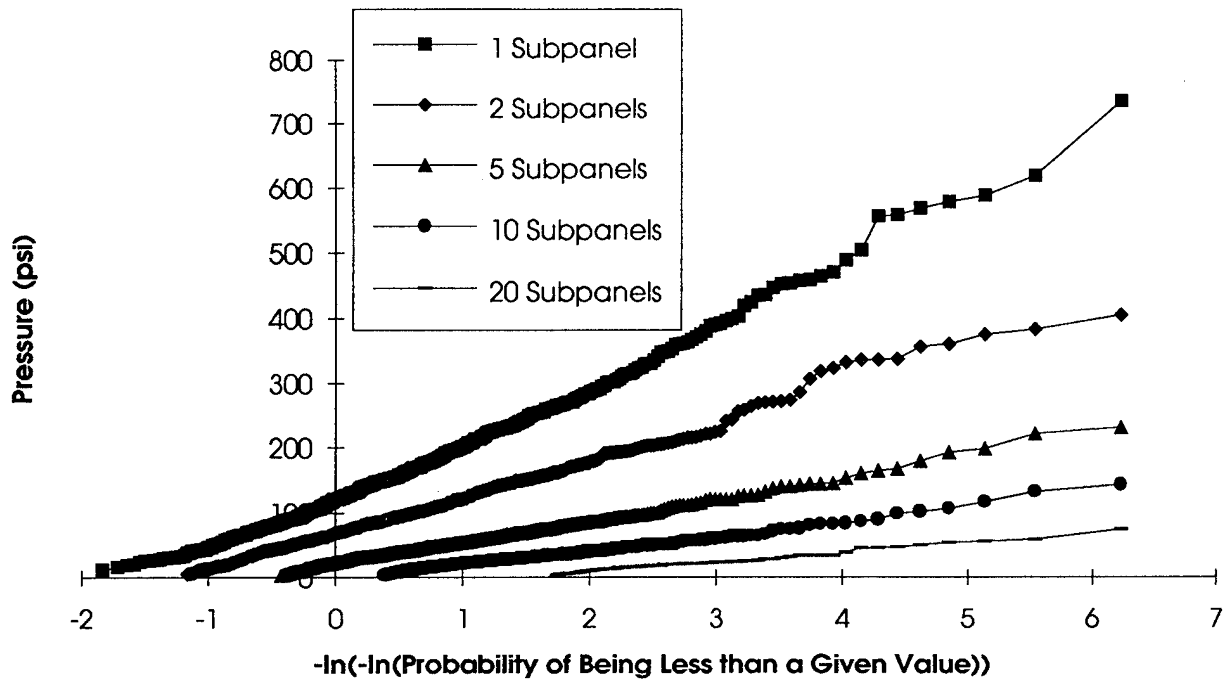


Figure 45. Extreme value distributions of pressures for different areas (various numbers of subpanels) on the bow panel.

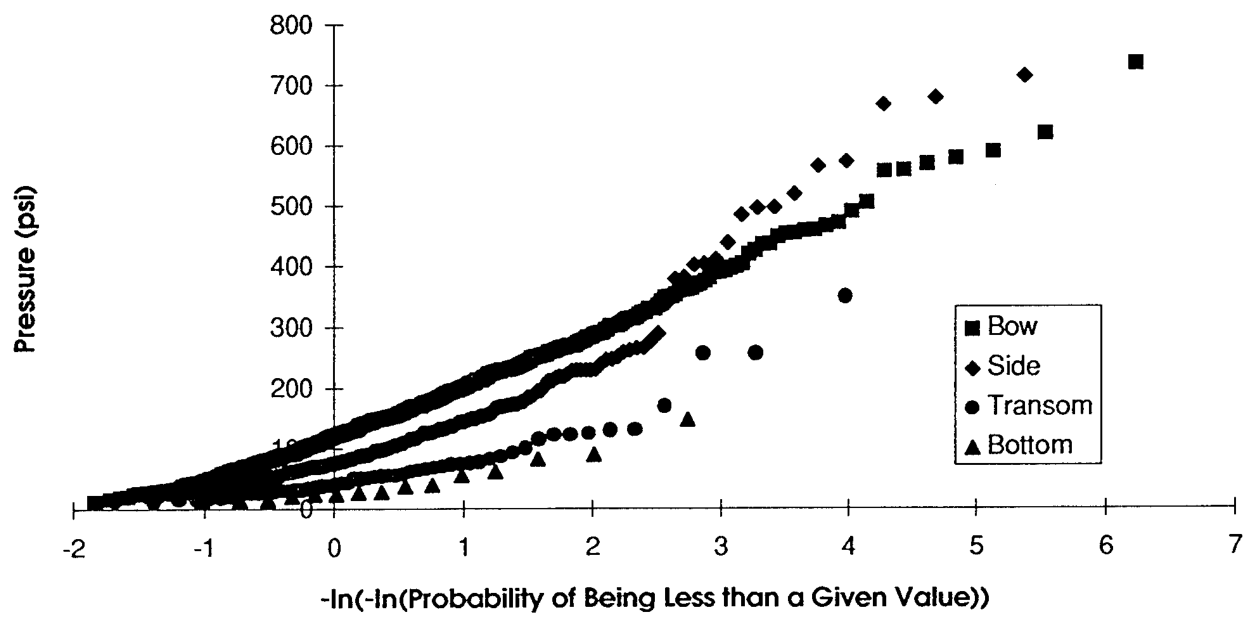


Figure 46. Extreme value distribution of single subpanel pressures for different panel locations.

show a change in slope. The change in slope could be caused by a mixing of two different failure processes or modes or the fact that the data set is small for these locations.

The impact force, the total local load on all subpanels, can be examined in the same manner. Results of this analysis are shown in Fig. 47. These extreme values also fit a Gumbel extreme value distribution (the regression coefficient is 0.9838), though the fit is not as good as the regression for single subpanel pressure shown in Fig. 44 (the regression coefficient is 0.9904). The extreme value distributions of total panel load for each panel location are shown in Fig. 48. The magnitudes of the load on each panel cannot be compared directly since they result from different sized and shaped panels, but several conclusions can be drawn from the figure. The character of all of the distributions is similar. The transom panel recorded surprising high forces in relatively few impacts even though the measurements were from one frame and the bow panel involved seven frames.

6.4 FREQUENCY OF IMPACT

Equally important to the statistical description of the impact loads is a description of the number of impacts that can be expected in a given operating period; i.e., a 1- to 3-yr return period, or the lifetime of the vessel. These impact frequencies are summarized for the *Palmer* in Table 8 for each hull panel and are further divided by the type of ice conditions as defined by the locale. The impact frequency analysis was performed by summing up the number of impacts that occurred on a given hull panel over a given length of time and noting the time duration between the date-time group of the first and last impacts. Durations of more than 1 hr between successive impacts were considered gaps where the ship was stopped for the night or for on-ice data collection. These gaps were not included in the analysis.

Considering the impact frequencies from the heavier ice conditions found in the vicinity of the South Orkney Islands first, both the bow panel and side panel averaged 10 to 11 impacts/hr. The impact frequency on the transom panel was about half of this at 6 impacts/hr and the bottom panel had an impact frequency of 3 impacts/hr. It should be noted, however, that impact frequency is a function of the threshold setting for the panel in question. A lower threshold setting results in a greater number of impacts being recorded for the same type of ice conditions. This explains the similarity between the bow and side panel impact frequencies since the threshold was set lower on the side in general. This data set includes the time spent backing and ramming through and maneuvering around the heavier ice features.

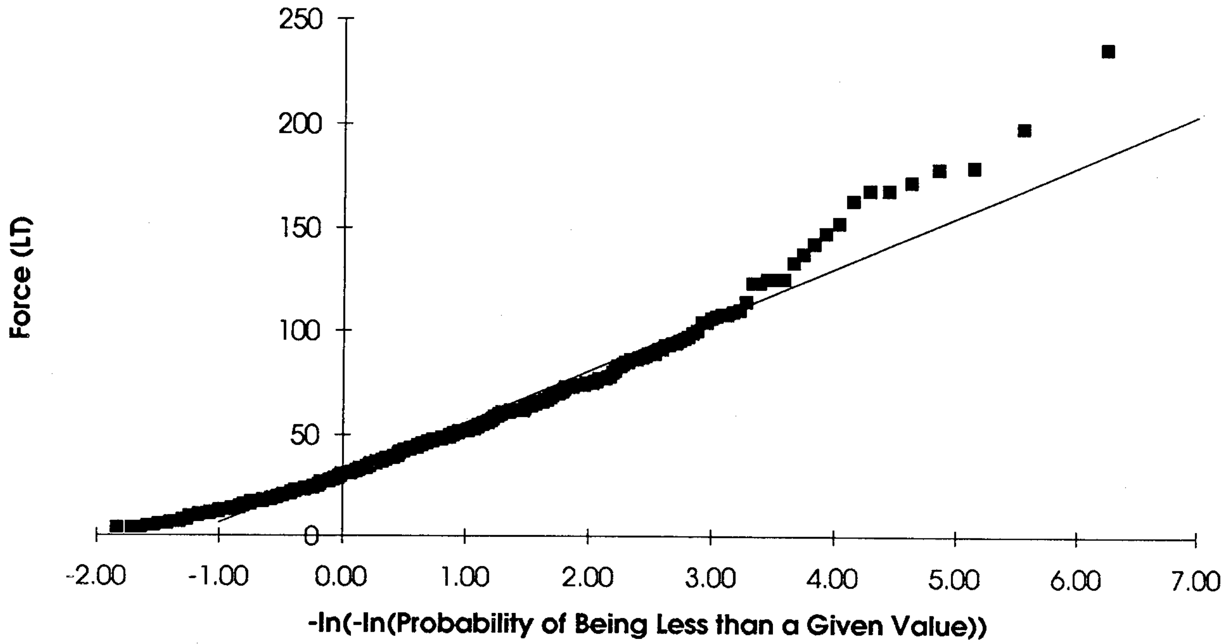


Figure 47. Extreme value distributions of total panel force for the bow panel.

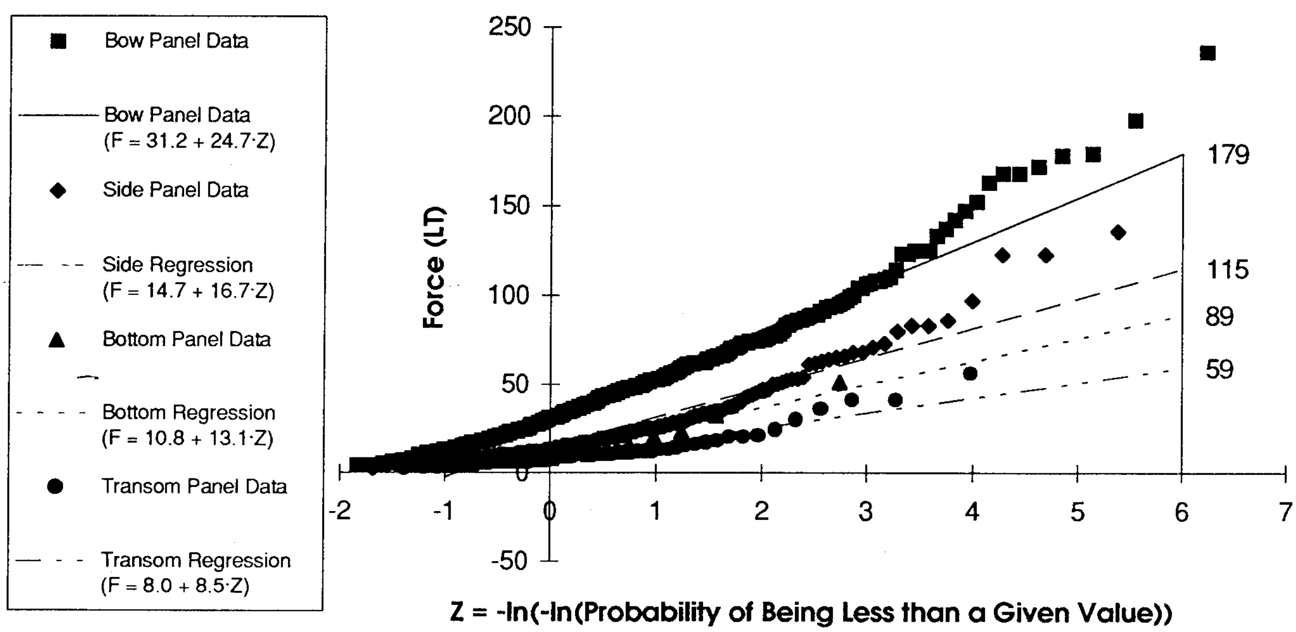


Figure 48. Extreme value distributions of total panel force for each panel location.

Table 8. Impact Frequency by Hull Panel and Locale

Hull Panel	Locale	Typical Threshold Setting ($\mu\varepsilon$)	No. of Recorded Impacts (No.)	Data Collection Time (hr)	Impact Freq. (No./hr)
Bow	S. Orkney Is.	27.5	468	55.2	10.1 ± 50%
Side	S. Orkney Is.	15.0	184	21.4	10.9 ± 38%
Bottom	S. Orkney Is.	5.0	7	2.3	3.2 ± 24%
Transom	S. Orkney Is.	10.0	50	10.0	5.9 ± 47%
Bow	S. Shetland Is.	15.0	34	2.8	31.4 ± 71%
Side	S. Shetland Is.	10.0	29	1.5	47.5 ± 80%

The data set for the lighter level ice conditions of the South Shetland Islands is much smaller than for the South Orkney Islands and insufficient impacts were recorded on the bottom and transom panels for impact frequency analysis. The impact frequencies were determined to be about 30 impacts/hr for the bow panel and 48 impacts/hr for the side panel. The impact frequencies are higher than for the frequencies for the same panels in the South Orkney Islands because of the lower threshold settings and the fact that the ship was stopped except for dedicated performance tests. It may also be that the impact frequencies are higher in the lighter ice conditions because of the absence of time needed for backing and ramming or the more frequent occurrence of small cusp-breaking events as compared to large ramming events. The higher frequency noted for the side panel compared to the bow panel is partly due to its lower threshold setting and the operating conditions, particularly during maneuvering tests, where the side panel would plow into the ice sheet during turns. At one point the *Palmer* stopped in the middle of a turn with an ice cusp right on the side panel causing multiple events to be triggered.

6.5 SHAPE OF THE CONTACT AREA

An important aspect of the ice impact loading is the extent of the load. The magnitude of the impact force and the average pressure influence the magnitude of the contact area. Recent work on ice loads have put forth the notion that ice loads are a line load extending along the waterline and across many typically vertical frames. The new Canadian Arctic Shipping Pollution Prevention Regulations (CASPPR) have adopted a loaded contact area aspect ratio

of 8 (load width along the waterline to load height along a typical transverse frame) for their design condition (Churcher et al., 1990). Results for the *Oden* did not support the notion of long, narrow line loads (St. John and Minnick, 1993a). In fact most of the loads on the *Oden's* bow panel were quite close to being the same width as height, i.e., an aspect ratio of 1. A similar analysis was done for the bow panel on the *Palmer*, and a summary of the frequency of load width to load height combinations is shown in Fig. 49. Considering that the gage spacing and frame spacing are roughly the same, then aspect ratios for the total contact area are near 1.0 up to 4 gage spacings and 4 frame spacings.

The frequency of occurrence of different aspect ratios for the *Palmer's* bow panel is summarized in Fig. 50. Ninety-five percent of all events, or 485 events of the 511 analyzed, had an aspect ratio of less than 2. There may well be a line of high pressure within the contact area, but analysis of the loaded contact area indicates a much more two-dimensional shape. The frequency of different loaded widths for the bow panel on the *Palmer* is shown in Fig. 51. There is a fairly even distribution of impacts with a load width of 1, 2, or 3 frame spacings comprising three-quarters of the data. The remaining one-fourth of the impacts have load widths of 4 frame spacings or greater with a frequency that decreases slightly for wider loads.

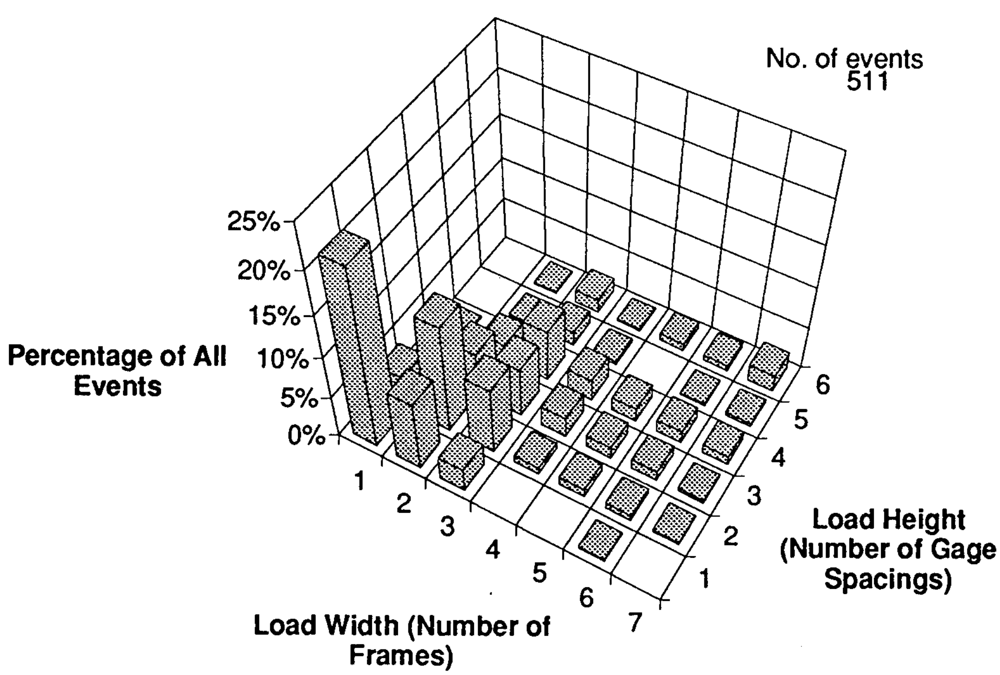


Figure 49. Bow panel frequency of contact areas of different widths and heights.

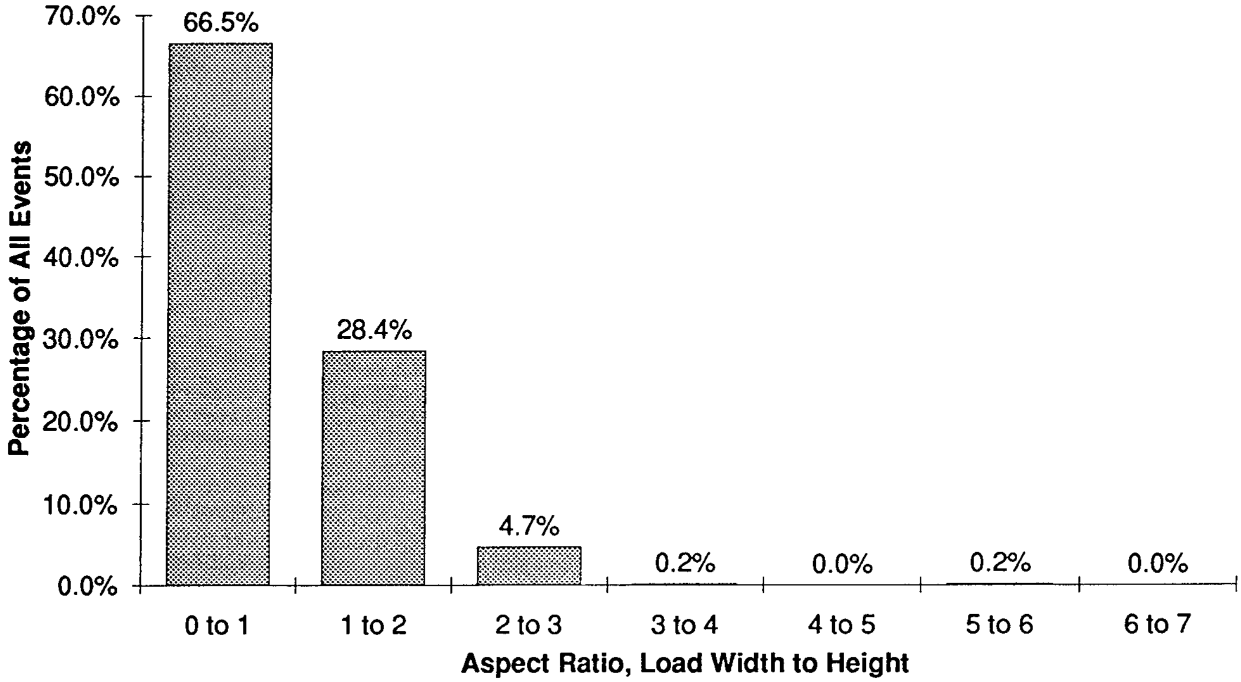


Figure 50. Bow panel frequency of contact areas of different aspect ratios.

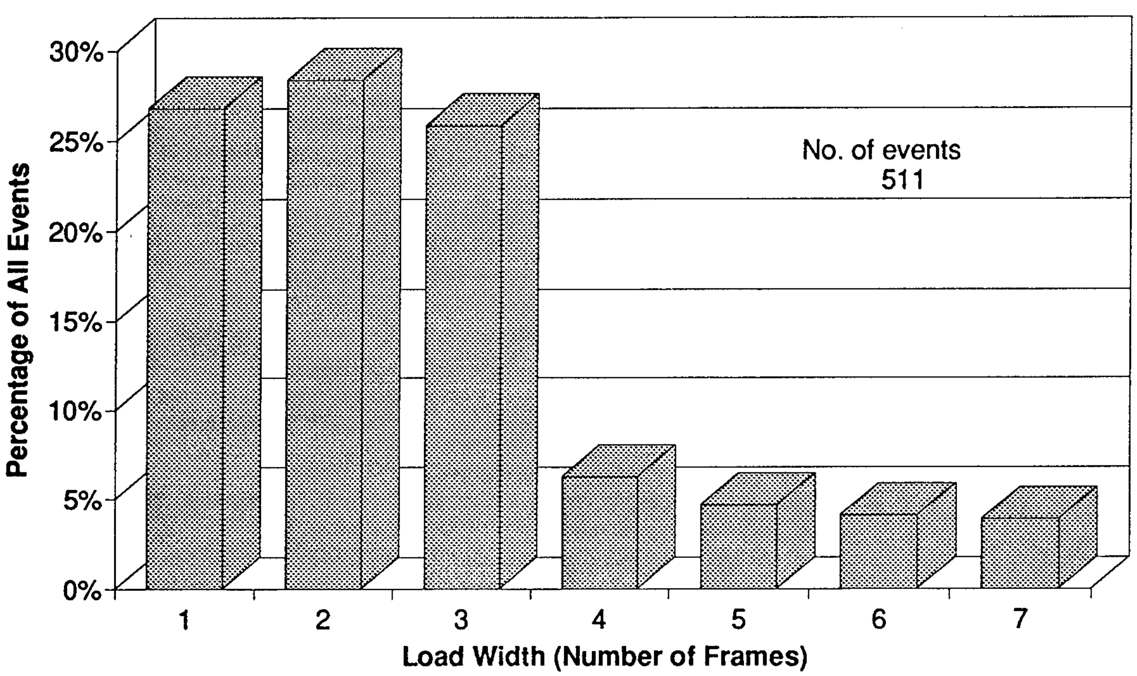


Figure 51. Bow panel load width frequency.

Similar analyses were performed for the side, bottom, and transom hull panels, but the results were inconclusive because the extent of these panels is too small. The side panel aspect ratio analysis with its 2 frame spacings and 3 gage spacings showed trends similar to the bow panel for aspect ratios near 1 once the fact that the frame spacing is twice the gage spacing is taken into account. All 217 side impact events were considered. The bottom panel analysis, on the other hand, with its 2 athwartship gage spacings and 3 longitudinal frame spacings shows a more uniform distribution of aspect ratios over the panel. Only 15 bottom impact events were considered, however. The transom panel consists on only one instrumented frame, and therefore, lacks the width necessary for aspect ratio analysis.

6.6 THE TRENDS WITH LOCATION ON THE SHIP

A comparison was conducted of the reduced impact results between the different instrumented hull panels on the *Palmer.* This was done with both the extreme pressure envelope curves and the extreme value distributions.

One way to compare the different sets of impact pressure data among the various hull panels directly is through the use of a pressure-area graph. All of the single subpanels on the *Palmer* have different sensor areas based on their frame spacing and gage spacing. These areas were given in Table 1. It was seen from the *Polar Sea* measurements and other data that the peak pressure over a given area decreases with increasing area approximately to the -0.2 power. Therefore, a smaller peak pressure should be expected for larger areas, given the same ice conditions. Shown in Fig. 52 is a pressure-area graph of the extreme pressure envelopes from all of the hull panels. The small area pressures recorded on the side and the bow are of similar magnitude. The curves for the side, bottom, and transom panels do not extend much beyond contact areas of 20 ft because their total panel area is smaller than the bow panel's total area.

The extreme envelope curves for the bow, side, and bottom panels all approach lines of constant force as the area increased, suggesting that the extreme events were captured within the measurement panel. The envelope curve for the bottom panel was therefore of a similar slope to the bow and side panel curves but at about one-third the magnitude. The shape and the lower pressures indicate that the total local load and therefore the contact areas were much smaller for the bottom panel. The shape of the pressure envelope for the transom panel shows that it was force limited because measurements were only made on one frame. It is presumed that some of the side impacts were limited in the same manner since the higher

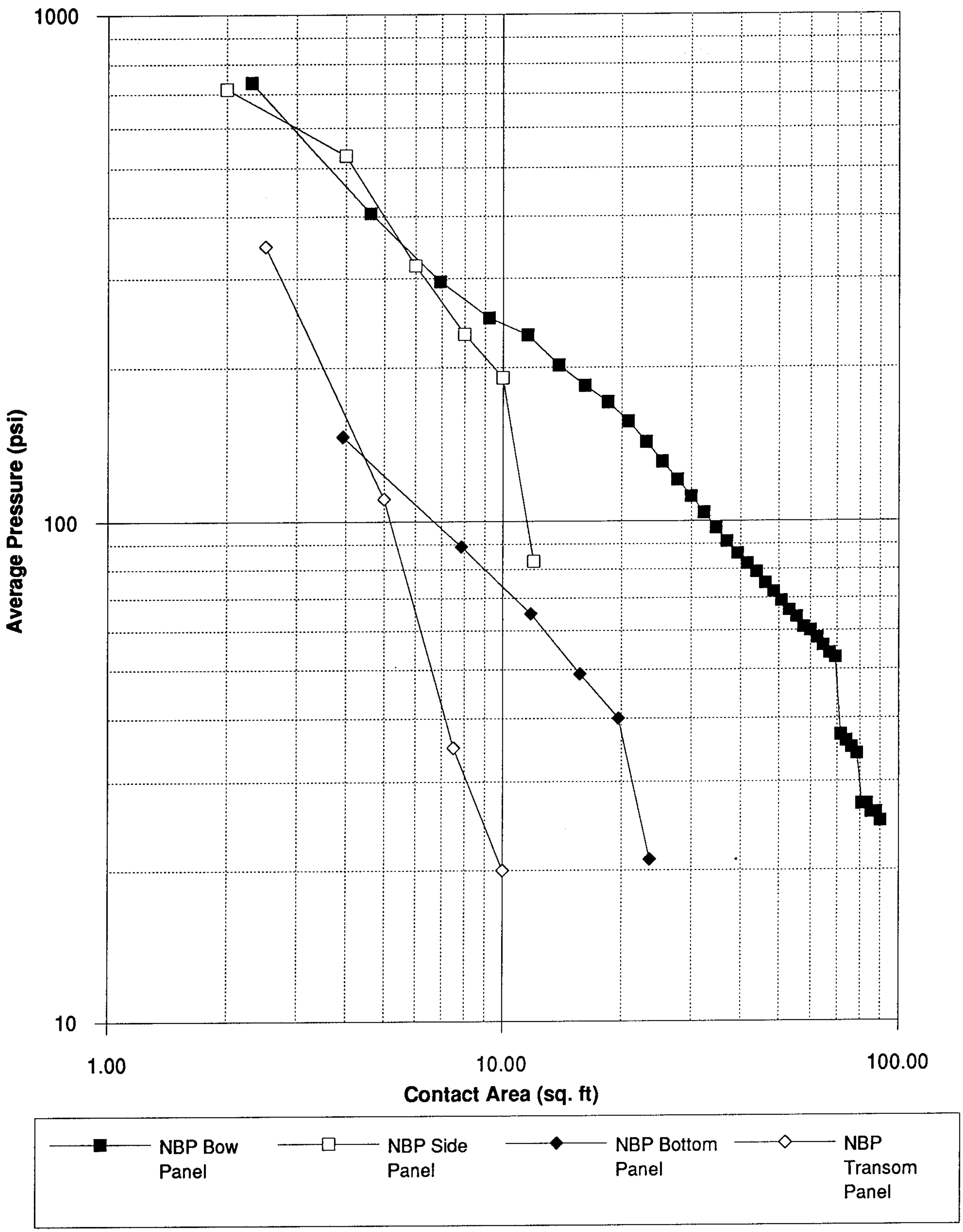


Figure 52. Comparison of extreme pressure for all hull panels versus contact area.

aspect ratio impacts tend to oriented along the hull. This effect does not influence the quality of the small area pressures but it does have some effect on the total local load at those locations. The extreme events on the side that generate the envelope curve were not limited by the size of the panel, however. The time history and the orientation of the load indicates that the contact area was contained on the panel. The trend in total local load is clear. The bow area is highest, followed by the side, then the transom and finally the bottom. Specific values of the peak force on the panels at each location are given in Table 7. The loads at different locations occurred as expected. The bow panel recorded the highest load of 236 LT (2.35 MN), the side panel the next at 136 LT (1.36 MN), the transom panel the next at 56 LT (0.56 MN), and the bottom the lowest at 51 LT (0.51 MN). Even though the measured loads on the transom and bottom are similar, a larger panel across the transom should indicate that the transom total local load is higher, perhaps even as high or higher than the side if a similar number of events are recorded.

A comparison of the extreme load per unit length envelopes versus frame length is shown in Fig. 53. Again the envelope curves for the bow and side panels fall right on top of each other while the envelope for the bottom and transom panels form a second set at a smaller load per unit length. The extreme load per unit length envelopes versus waterline length are given in Fig. 54 with similar results. Only one point is plotted for the transom panel because only one frame was instrumented. Also note that there is practically no difference between the bottom panel envelopes between Figs. 53 and 54 indicating that this parameter is not affected by orientation for lengths up to 4 ft. Therefore, ice impacts occurring on the bottom of the vessel have either circular contact areas or oval contact areas that have orientations that are uniformly distributed over all directions.

The extreme value distributions for single subpanel pressures for each panel location were presented in Fig. 46. All the distributions look reasonably linear with the exception of the side panel that shows a change in slope for the highest 15 data points. These data points were examined in detail to see if they all occurred in similar conditions. They did not. They are spread evenly over the entire data collection period though they occur at the times the ship was experiencing the heaviest ice conditions. It is not surprising since these data points occurred during the severest conditions because they are the extremes of the data. The change in slope could be caused by a mixing of two different ice failure modes, or ship operations. Maneuvering loads versus straight ahead running would be one example. The extremes of the data are consistent in magnitude with the extremes of pressure at the bow. An icebreaking process such as incidental impact of small ice pieces under normal transit

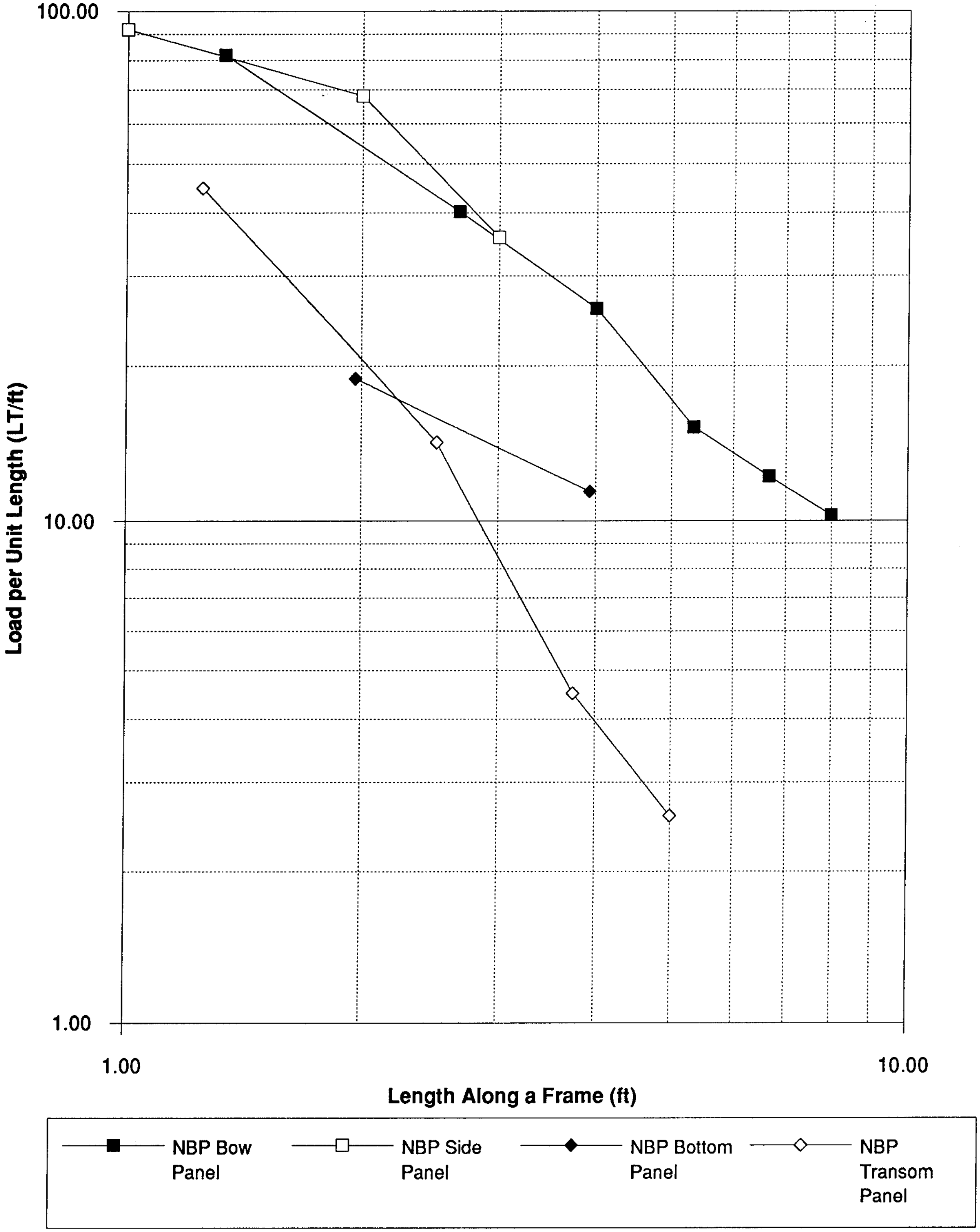


Figure 53. Comparison of extreme load per unit length for all hull panels versus frame length.

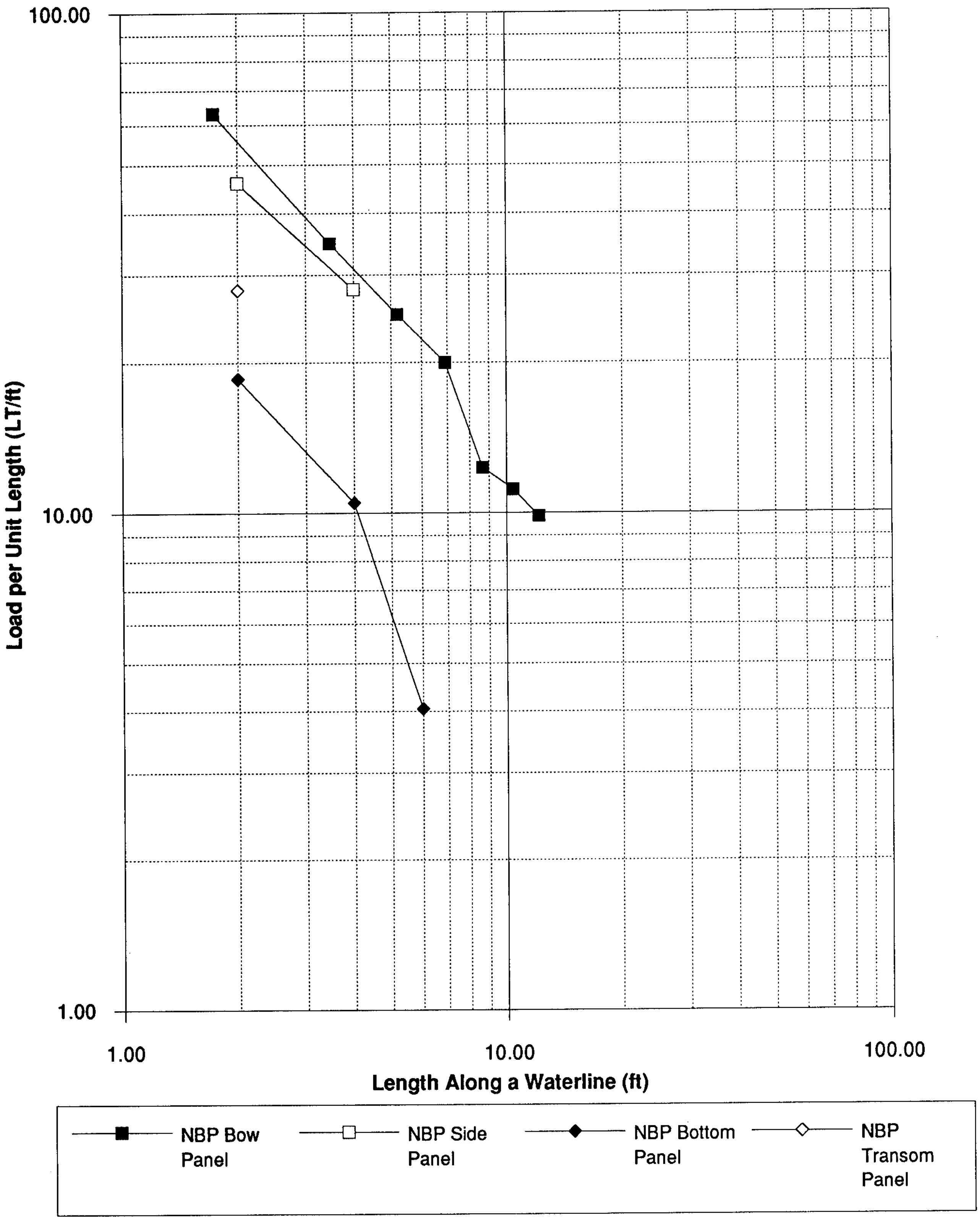


Figure 54. Comparison of extreme load per unit length for all hull panels versus waterline length.

conditions could limit the force of the impact such that the measured pressures are reduced for many of the impacts

The extreme value distributions of total panel load for each panel location were presented in Fig. 48. The character of all of the distributions is similar. The change in slope that was event in the single subpanel pressure distribution for the side panel is conspicuously absent in the force distribution, however there is a small increase in force for those data points. Regression of the force distributions is useful in determining the relative magnitude in local load between the various locations. The side loads are approximately 65 percent of the bow loads and the bottom loads are about 50 percent of the bow loads as shown in Fig. 48. The transom panel forces do not reflect the loads from the entire contact area since only one frame was measured. It is still possible to assess the relative magnitude of the forces on the transom to the bow forces by comparing the transom results to the maximum frame loads for the bow panel, however. Results of this comparison are shown in Fig. 55. Similar to the bottom local loads, the transom loads were also approximately 50 percent of the bow loads.

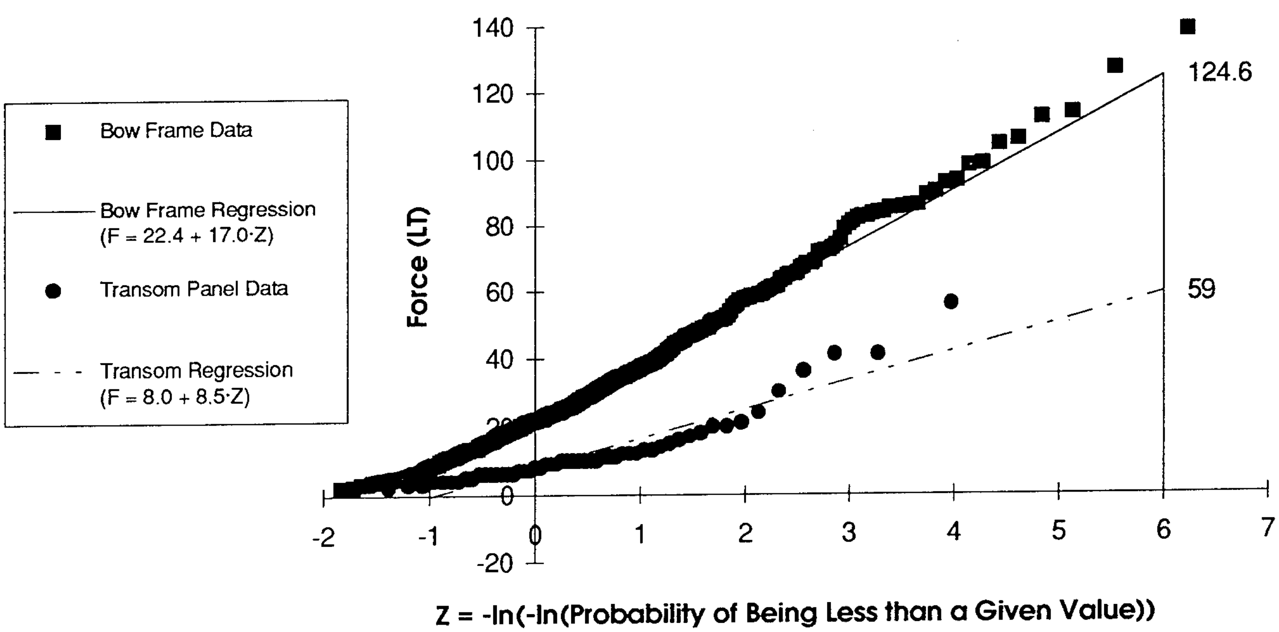


Fig. 55. Extreme value distributions of frame load for the bow and transom panel locations.

7. COMPARISON WITH THE *POLAR SEA* AND *ODEN* DATA SETS

The objectives of the loads program on the *Nathaniel B. Palmer* were to determine the effect displacement on ice impact loads and to compare impact loads measured at different areas on the ship. . The *Nathaniel B. Palmer* has a conventional icebreaking bow similar to the *Polar Sea* but has only half the displacement. For the displacement assessment, it was intended that the *Nathaniel B. Palmer* loads be compared with the *Polar Sea* loads collected in similar ice conditions. Her waterline half-angle at the bow hull panel is 27° and the flare angle from vertical is 42°. The instrumented panel on the *Polar Sea* had a waterline angle of 30° and the flare angle to the vertical was 54° (St. John et al., 1984). The closeness of the *Palmer's* and *Polar Sea's* bow angles at the instrumented bow panels indicates their similar orientation to on-coming ice.

The objective in making the measurements aboard *Oden* was to examine the effect of differences in bow shape on the local impact loads as compared to the *Polar Sea's* conventional icebreaking bow. *Oden* was chosen because it was very close to the same size (displacement) as the *Polar Sea*, but with a much different bowform, and a large body of information on ice loads had already been collected on *Polar Sea*. *Oden's* waterline half-angle at the measurement panels is 90°, and the angle of the panel to the vertical is 70°. Even though there was a significantly different orientation of the measurement panels to the on-coming ice between the *Oden* and *Polar Sea*, it was thought that there would be little difference in the impact pressures in the same type of ice. The pressures would be a function of the strength of the ice and how it fails, and therefore, given many impacts, the extremes of the two data sets should be similar. Results showed that this was the case.

The *Polar Sea* data was therefore the baseline data set for comparison of both the *Oden* and the *Palmer* measurements because of the volume of data collected on *Polar Sea* and the fact that impacts were collected in virtually every kind of sea ice conditions. The *Oden* measurements were collected entirely in high concentrations of Arctic summer multiyear ice. These data from *Oden* were compared with the two summer deployments of the *Polar Sea* to the Beaufort Sea in 1982 and 1984 where concentrations of multiyear ice were encountered. The Palmer encountered first and second year ice of similar strength to Arctic winter first year ice. It was not intended nor is it appropriate to compare the *Oden* and the *Palmer* data sets directly because they occurred in different types of ice. Both data sets must be compared to different data sets for *Polar Sea* corresponding to the ice conditions that provide the closest match.

The ice conditions and flexural strengths that the *Palmer* saw while backing and ramming in the heavy ice conditions east and south of the South Orkney Islands are very similar to the thick winter first year ice of the Bering Sea. Voelker, in his summary of the data collection program on the *Polar* Class (Voelker, 1990), described the zones of environmental severity around Saint Lawrence Island in the Bering Sea (zones 5 and 6 in his report) as being "highly dynamic ice conditions with ice drifting at 0.3 to 0.5 kt and ice thicknesses ranging from 1 to 4 ft. Pressure ridges, rubble ice floes, pressured ice conditions, as well as open leads, can be expected throughout...". A summary of 100 cores taken in the first year ice of the Bering Sea over numerous deployments from 1979 to 1985 indicate that the flexural strength of the ice ranges from 58 to 96 psi (Voelker, 1990). Loads measured on the *Polar Sea* on a winter transit through the Bering Sea in 1983 (St. John et al., 1984; Voelker et al., 1983) provide an ideal database for comparison with the *Palmer* loads. The average flexural strength from 15 first year cores from the 1983 winter deployment of *Polar Sea* was 78.4 psi using Vaudrey's formula (Voelker et al., 1983; Vaudrey, 1977). The strength data from the 1983 winter deployment is in very good agreement with the data collected on the *Palmer* which showed an average flexural strength according to the same formulation of 75 psi in the South Orkney Islands and 79 psi at King George Island (Williams, 1992b).

Loads measurement was also done on the 1984 austral summer deployment of *Polar Sea* to McMurdo Sound in Antarctica (St. John et al., 1986), but the ice strength data from this deployment showed that the ice was much weaker, an average flexural strength of 40.2 psi using Vaudrey's formulation for the six long cores taken (Voelker and Geisel, 1984). Since the data was taken during the McMurdo break-in, all the loads come from operations in landfast level ice of 3 to 6 ft in thickness.

7.1 COMPARISON OF EXTREME PRESSURES

The maximum first year ice pressures experienced by the *Polar Sea* were 745 psi (5.1 MPa) in the North Bering Sea and 594 psi (4.1 MPa) in Antarctica (St. John et al., 1990b). These pressures bracket the 735 psi maximum single subpanel pressure measured on the bow panel on the *Palmer*. A comparison of the extreme envelope curve of pressure versus contact area is shown in Fig. 56. First to be noted is the excellent agreement between the data sets for *Polar Sea* and the side and bow panel of the *Palmer*. The *Palmer* bow panel data are bracketed by the *Polar Sea* data sets. The *Polar Sea* load measurement panel had slightly smaller subpanels with a subpanel area of 1.63 ft^2 (0.152 m^2) compared to 2.31 ft^2 (0.21 m^2) on the

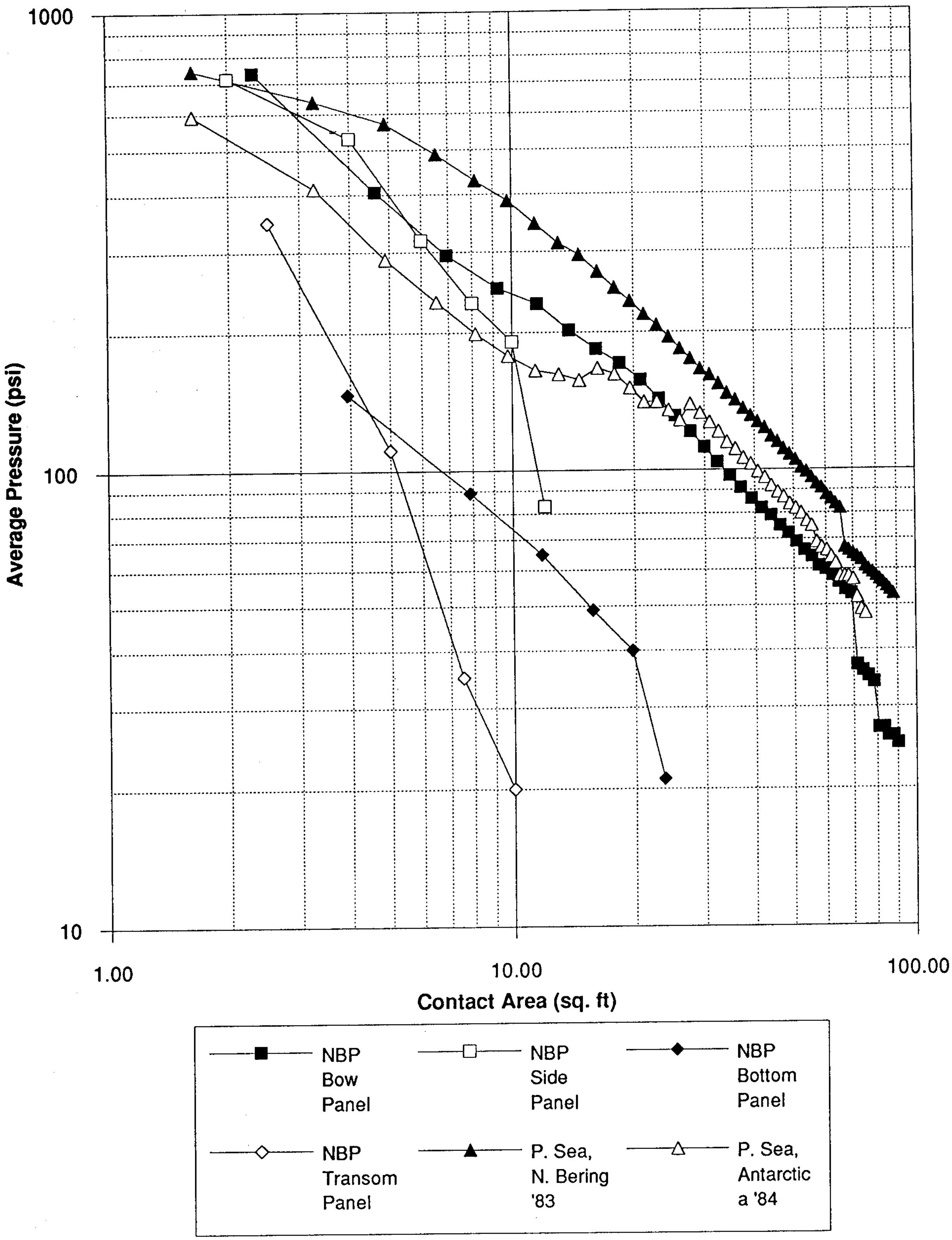


Figure 56. Comparison of extreme pressure versus contact area for the *Palmer* and *Polar Sea* data sets in similar ice conditions.

Palmer's bow panel. When ice strength and panel size are considered the small area pressure show excellent agreement.

A comparison of the extreme load per unit length envelopes versus frame loaded length and waterline loaded length are shown in Figs. 57 and 58 for all four hull panels on the *Palmer* and both *Polar Sea* deployments. Generally speaking, the envelope curves for the bow and side panels fall right on top of each other and are in line with the *Polar Sea* data. The envelope curves for the *Palmer's* bottom and transom panels have a smaller load per unit length by comparison.

A similar comparison of extreme envelope pressures was made between measurements from the *Polar Sea* and *Oden* in similar ice conditions (summer multiyear) to determine if bowform had a significant effect on the ice impact loads (St. John and Minnick, 1993a). The results gave several important conclusions. The first was that the local impact pressures at the bow did not significantly differ between the two ships in similar ice conditions. This result leads one to conclude that hullform does not effect local pressures, at least in areas where the hull is relatively flat over the impact area. Local impact pressure appears to be related to ice failure properties. The additional comparison between the *Polar Sea* and *Nathaniel B. Palmer* measurements in similar ice conditions indicates that displacement also does not significantly affect local impact pressures over small contact areas, at least in the bow region. Direct comparisons can not be made between the *Palmer* and *Oden* because of the different ice conditions encountered during their deployments.

The extreme value distributions of single subpanel pressures from the bow of the *Nathaniel B. Palmer* are compared with those from the bow panel of the *Polar Sea* in Fig. 59. The *Polar Sea* measurements presented in the figure are the data collected in the Bering Sea in the winter of 1983. Since the *Polar Sea* subpanels are smaller than the *Nathaniel B. Palmer* subpanels, both the results for one and two subpanels are presented for *Polar Sea* to bracket the *Nathaniel B. Palmer* measurement area. Results show that the one subpanel *Nathaniel B. Palmer* pressures fall between the one and two subpanel pressures of the *Polar Sea* as they should based on decreasing pressure with area. There is excellent agreement between the two data sets and the results lend credence to the supposition that impact pressure data is driven by the ice conditions and not the ship. Similar ice conditions, especially ice type (first year versus multiyear), determine the expected pressures, not the ship size or the impact speed.

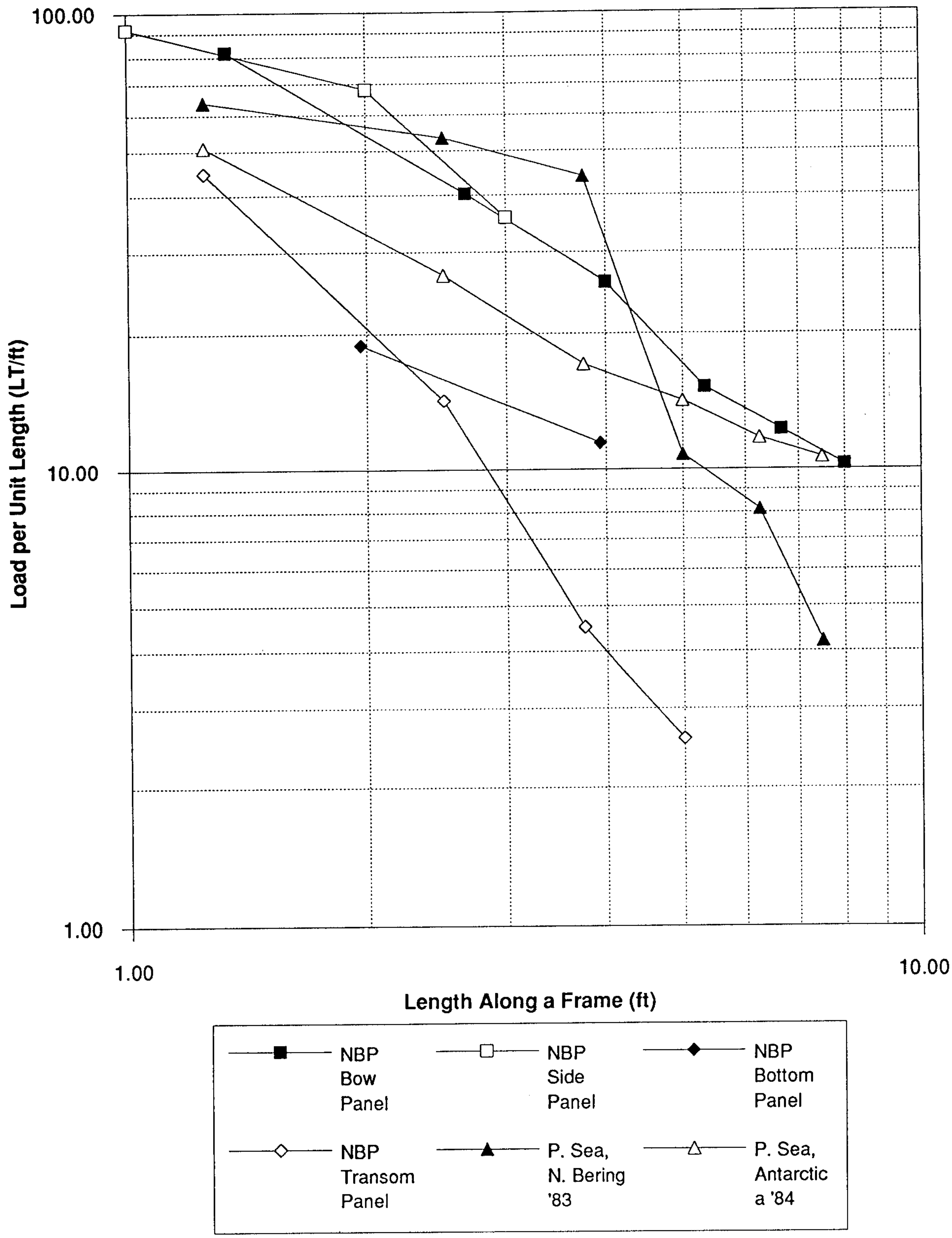


Figure 57. Comparison of extreme load per unit length versus frame length for the *Palmer* and *Polar Sea* data sets in similar ice conditions.

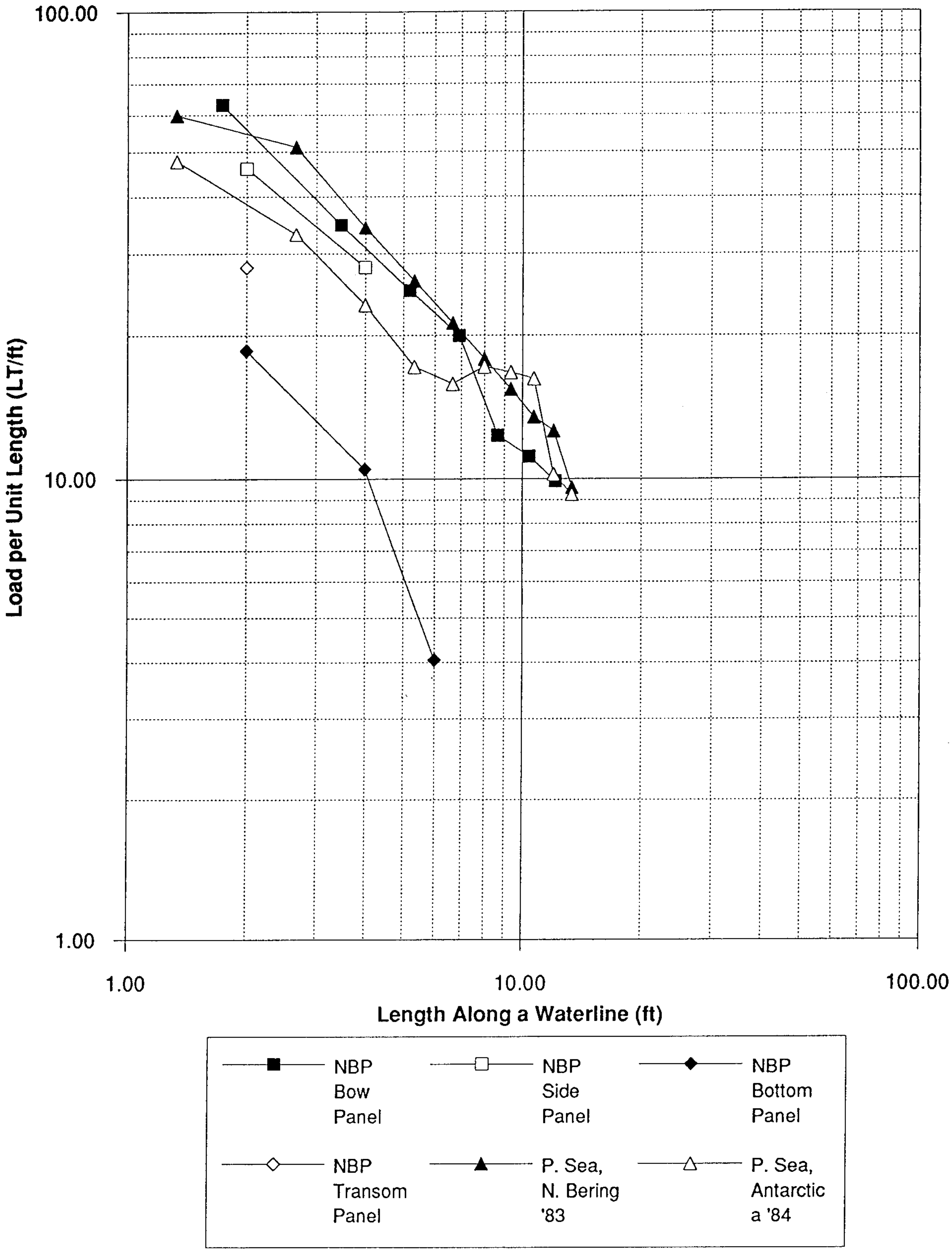


Figure 58. Comparison of extreme load per unit length versus waterline length for the *Palmer* and *Polar Sea* data sets in similar ice conditions.

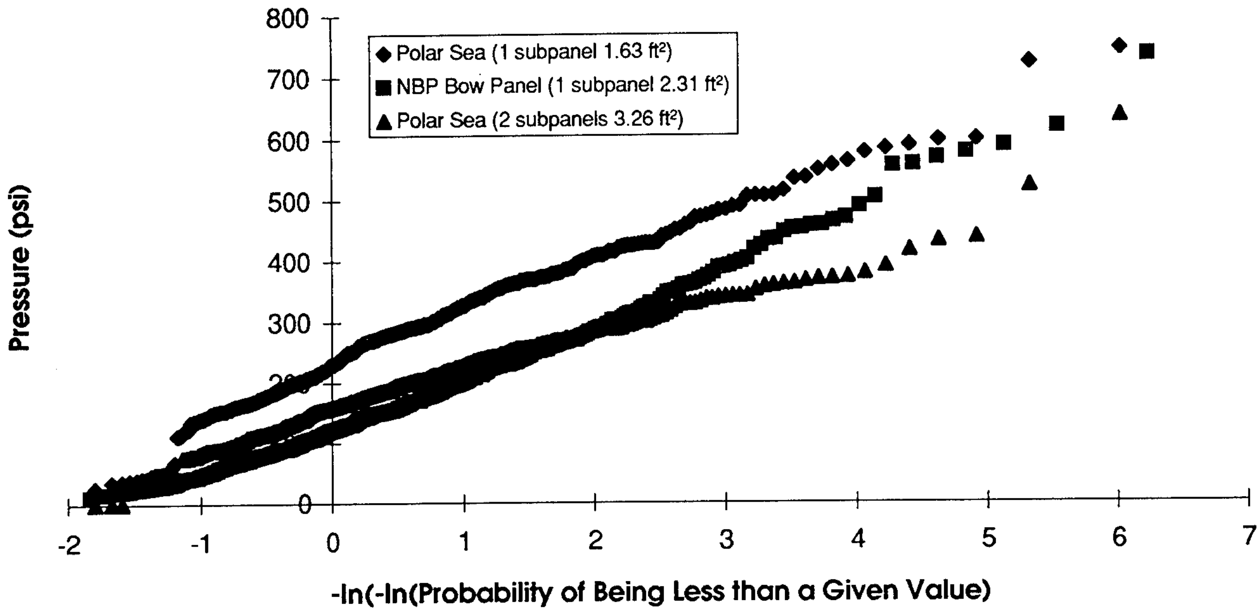


Figure 59. Comparison of extreme value distributions of single subpanel pressure for *Nathaniel B. Palmer* and *Polar Sea.*

7.2 COMPARISON OF TOTAL LOCAL LOADS

The extreme total local load for the *Palmer* was collected on the bow panel and had a magnitude of 236 LT. It was shown in the previous section that the most appropriate data set from the *Polar Sea* to compare with the *Palmer* is that collected in the Northern Bering Sea in the winter of 1983. For this data set, the *Polar Sea* measured a maximum total local load of 359 LT. The panels were of similar size and shape and the orientation to the ice was quite similar as described in the previous section. The *Palmer's* panel was 8.0 ft by 12.1 ft while the *Polar Sea's* panel was 7.3 ft by 13.3 ft.

Extreme value distributions of total local load on the *Polar Sea* panel in the North Bering Sea and the *Palmer* bow panel are given in Fig. 60. Both sets of data are fit with a Gumbel type distribution and the ratio of the slopes is 47.8/24.7 or 1.94. The ratio of the forces taken from the regressions at the same probability (in this case 0.9975 or Z = 6) is 390/179 or 2.18. The *Palmer* was operating at a displacement of approximately 6500 LT when the data were taken and the *Polar Sea* was operating at a displacement of about 13,000 LT. One of the

objectives of this study was to see how the loads and pressures were effected by ship size. It appears that the total local loads at a location scale approximately linearly with displacement.

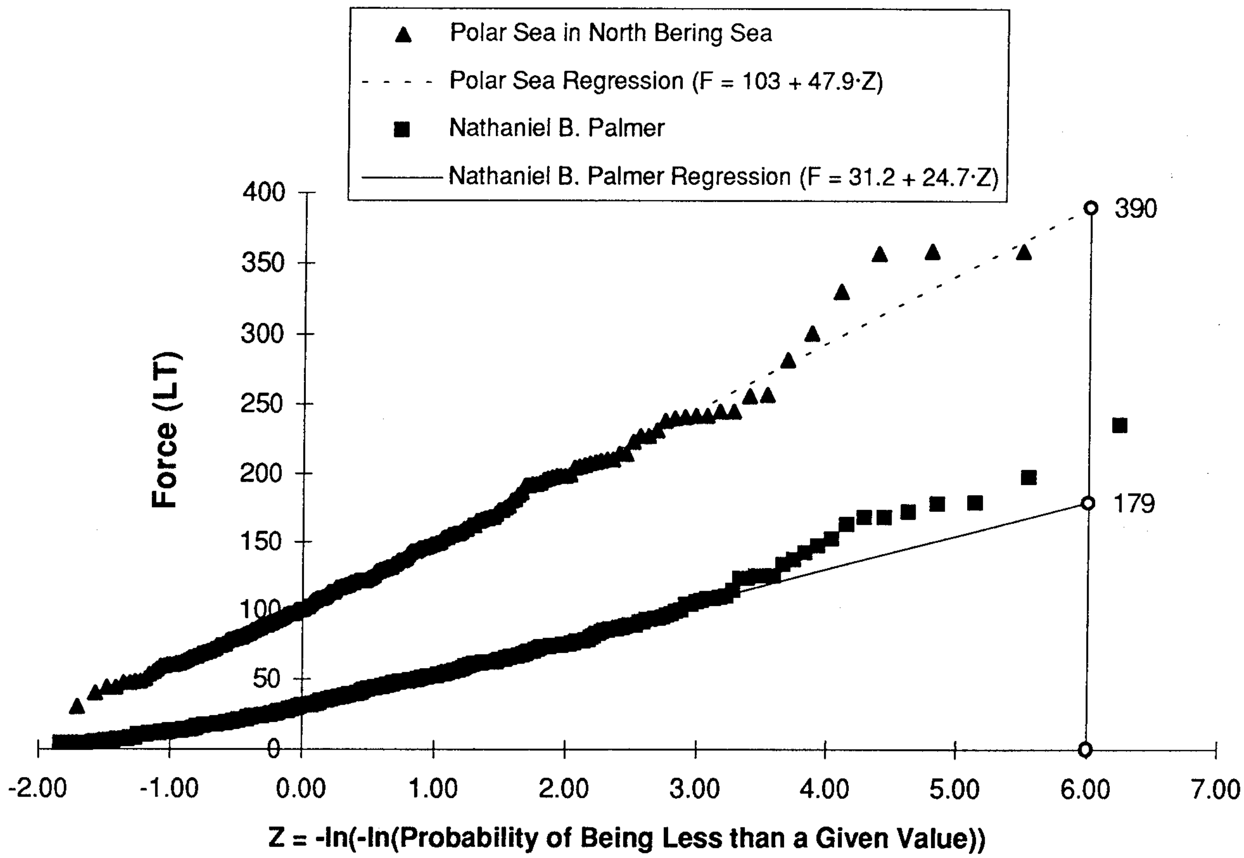


Fig. 60. Comparison of total local load on the bow panels of *Polar Sea* and *Nathaniel B. Palmer.*

8. CONCLUSIONS

The local load measurement system performed well during the 1992 winter ice tests aboard the *Nathaniel B. Palmer* and an excellent set of data was collected. The encountered ice conditions could be divided into two sets. The first and heavier ice conditions were found in the vicinity of the South Orkney Islands and were typically 90 to 100 percent coverage of 2- to 4-ft (0.6- to 1.2-m) thick ice with about 10 to 20 percent concentration of ice greater than 4 ft (1.2 m) in thickness. The average flexural strength was determined to be 75 psi (515 kPa) according to Vaudrey's formulation for ice strength from brine volume. The second set of distinct ice conditions was found in the frozen bays of King George Island in the South Shetland Islands. This ice was 1 to 2 ft thick with an average flexural strength of 79 psi (545 kPa).

Overall a large statistical database of 796 events was collected on all panels. Simultaneous events on different hull panels were a frequent occurrence with 16 percent of all of the impact events being the result of simultaneous impacts. The majority of events (90 percent) were recorded in the vicinity of the South Orkney Islands. The majority were also recorded on the bow panel (64 percent) with the second greatest number (27 percent) on the side panel. The instrumented transom frame recorded 7 percent, and the bottom panel 2 percent.

The pressure and force time-histories were consistent with previous measurements in their shape and typical rise times. The pressure versus area curves also exhibited a similar shape, a flat, slightly decreasing slope at small areas that approached a line of constant force (much steeper slope) at larger areas. In some cases the curves of pressure versus contact area indicated that the pressure dropped off more quickly than expected based on previous measurement programs, however, this was attributed to smaller contact areas and the smaller overall extent of the side, bottom, and transom panels, in some cases. Side impact single subpanel pressures were found to be as high as the highest bow impact single subpanel pressures.

Ice impact loads and pressures did not have a clear trend with ice thickness, ice concentration, or ship speed. Peak loads or pressures occurred at the most common ice thickness, ice concentration, and speed, indicating the random nature of the loading; i.e., more impacts result in higher extremes. Expected trends such as increasing total force with

speed and ice thickness were over-shadowed by these random effects. These results are consistent with the *Polar Sea* and *Oden* results.

An analysis of the ice impact frequency indicates that this parameter depends on ice conditions, hull panel location, and of course, the threshold setting of the instrumentation system. In the heavier ice conditions of the vicinity of the South Orkney Islands both the bow panel and side panel averaged 10 to 11 impacts/hr. The impact frequency on the transom panel was about half of this value or 6 impacts/hr and the bottom panel had an impact frequency of 3 impacts/hr. In the lighter level ice conditions of the South Shetland Islands the impact frequencies were determined to be about 30 impacts/hr for the bow panel and 48 impacts/hr for the side panel. The increase in impact frequency for the lighter ice conditions was believed to be due to a combination of lower threshold settings in lighter ice conditions, the fact that the ship was stopped except for dedicated performance tests, and the absence of time needed for backing and ramming.

Contact areas were, in general, quite localized and of small aspect ratio. Ninety-five percent of the impacts on the bow panel had an aspect ratio less than 2 (load width to height). This is similar to the *Oden* results for the shape of the contact area.

A comparison of impact pressures between the different hull panels on the *Palmer* using extreme pressure versus contact area envelope curves indicated that similar pressures could be expected for contact areas less than 10 ft^2 (1 m^2) for the bow and side portions of the shell plating. The extreme envelope curves for the bow, side, and bottom panels all approach lines of constant force as the area increased, indicating that the extreme events were captured within the measurement panel. The envelope curve for the bottom panel was therefore of a similar slope to the bow and side panel curves but at about one-third the magnitude. This indicates that the total local load and therefore the contact areas were much smaller for the bottom panel. The pressure envelope for the transom panel was force limited because only one frame was instrumented. This effect does not influence the quality of the small area pressures but it does have some effect on the total local load at those locations.

The *Palmer* data was compared with two deployments of the *Polar Sea* in similar ice conditions. The first deployment involved a passage through the North Bering Sea in winter 1983 while the second was a summer deployment to McMurdo Sound in Antarctica in 1986. The ice conditions encountered by the *Polar Sea* in the North Bering Sea come closest to matching those found by the *Palmer* in the Weddell Sea. The extreme envelope of this data

set is in excellent agreement with the data sets for the side and bow panel of the *Palmer* for small area pressures.

Ice impact statistics were also computed. The pressures appeared log-normally distributed and extremes of the data are fit well with Gumbel extreme value distributions. The extreme value distributions of single subpanel pressures from the bow of the *Nathaniel B. Palmer* were compared with 1 and 2 subpanel pressures from the bow panel of the *Polar Sea* for data collected in the Bering Sea in the winter of 1983. Data from the slightly larger *Palmer* subpanel were bracketed by the *Polar Sea* data reinforcing the excellent agreement in small area pressures.

Extreme value distributions of total local load on the *Polar Sea* panel in the North Bering Sea and the Palmer bow panel were also compared. Both set of data fit a Gumbel type distribution and the ratio of the slopes was 47.8/24.7 or 1.94. The ratio of the forces taken from the regressions at the same probability was 390/179 or 2.18. These ratios are consistent with the ratio of the two ships' displacements, 13,000/6500 or a ratio of 2.

In summary, the objectives of the program were two measure the ice impact loads on the Nathaniel B. Palmer and compare them to the appropriate data sets for the Polar Sea. Specific objectives were to quantify the influence of ship size on locals loads and pressures and to quantify the changes in those loads and pressure with different locations on the ship. All of these objectives were achieved for the *Palmer*. A summary of specific results is as follows:

- Small area pressures are related to ice failure and therefore the ice type.
- Small area pressures are independent of ship speed and size.
- Total local load is controlled by the momentum of the ship as well as the mass and strength of the ice.
- Total local load scales roughly proportional to ship displacement for ships operating at similar ranges of speed in similar ice conditions.
- If local loads from ice failure are high enough any area of the ship can generate high small area pressures (the data supports the concept of a pressure asymptote that is related to the failure properties of the ice).
- Small local loads such as those measured on the bottom result in small contact areas and lower pressures that are limited by the force of the impact (the pressures cannot reach the pressure asymptote).
- Loads on the side were about 65 percent of those on the bow loads
- Loads on the bottom were about 50 percent of those on the bow loads
- Loads on the transom were also about 50 percent of the bow loads

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APPENDIX A

SUMMARY
OF
CALIBRATION FACTORS

Table A-1. Hull Loads Measurement System Calibration Data

Ship Area	Chan No	Gage ID	Active Arms	Gage Resist Ω	Wire Resist Ω	K	Excit v	Gain	Shunt Resist Ω	Sim Strain με	Sim Output v	Strain με	Zero Level v	Cal Neg v	Cal Pos v	Delta Factor v	Cal Factor με/v
Fwd	1	11	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	851	0.01	-4.21	4.23	4.22	207.4
	2	21	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	842	0.01	-4.17	4.18	4.18	209.7
	3	31	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	865	0.01	-4.28	4.30	4.29	204.1
	4	41	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	866	0.01	-4.29	4.30	4.30	203.8
	5	51	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	869	-0.01	-4.32	4.30	4.31	203.1
	6	61	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	869	0.00	-4.32	4.30	4.31	203.1
	7	12	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	863	0.02	-4.26	4.30	4.28	204.5
	8	22	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	860	0.00	-4.27	4.26	4.27	205.3
	9	32	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	870	0.00	-4.32	4.31	4.31	202.9
	10	42	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	856	0.00	-4.25	4.25	4.25	206.1
	11	52	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	878	-0.02	-4.38	4.33	4.36	201.0
	12	62	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	862	-0.01	-4.28	4.27	4.28	204.8
	13	13	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	855	0.01	-4.24	4.24	4.24	206.5
	14	23	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	863	0.00	-4.29	4.27	4.28	204.5
Bow	15	33	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	847	0.01	-4.19	4.21	4.20	208.4
	16	43	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	865	0.01	-4.28	4.30	4.29	204.1
	17	53	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	857	0.01	-4.24	4.26	4.25	206.0
	18	63	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	850	0.00	-4.22	4.21	4.22	207.7
	19	14	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	853	0.00	-4.24	4.22	4.23	207.0
	20	24	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	856	0.00	-4.25	4.24	4.25	206.2
	21	34	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	857	0.00	-4.26	4.24	4.25	206.0
	22	44	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	856	0.00	-4.30	4.19	4.25	206.2
	23	54	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	853	0.02	-4.22	4.24	4.23	207.0
	24	64	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	848	-0.01	-4.23	4.18	4.21	208.2
	25	15	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	857	0.00	-4.26	4.24	4.25	206.0
	26	25	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	854	0.00	-4.24	4.23	4.24	206.7
	27	35	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	853	0.01	-4.23	4.23	4.23	207.0
	28	45	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	840	0.01	-4.16	4.17	4.17	210.2
	29	55	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	845	0.00	-4.20	4.18	4.19	208.9
	30	65	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	853	0.00	-4.23	4.23	4.23	207.0

Table A-1. Hull Loads Measurement System Calibration Data (Concluded)

Ship Area	Chan No	Gage ID	Active Arms	Gage Resist Ω	Wire Resist Ω	K	Excit v	Gain	Shunt Resist Ω	Sim Strain με	Sim Output v	Strain με	Zero Level v	Cal Neg v	Cal Pos v	Delta Factor v	Cal Factor με/v
	31	16	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	856	0.00	-4.26	4.24	4.25	206.1
	32	26	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	844	0.00	-4.19	4.18	4.19	209.2
	33	36	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	862	0.00	-4.28	4.27	4.28	204.8
	34	46	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	853	0.00	-4.24	4.22	4.23	207.0
	35	56	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	859	0.02	-4.23	4.29	4.26	205.5
	36	66	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	863	0.01	-4.26	4.30	4.28	204.5
	37	17	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	860	0.00	-4.27	4.26	4.27	205.3
	38	27	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	859	0.02	-4.24	4.28	4.26	205.5
Bow	39	37	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	861	0.00	-4.28	4.26	4.27	205.0
	40	47	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	867	0.01	-4.30	4.30	4.30	203.6
	41	57	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	852	0.01	-4.22	4.23	4.23	207.2
Aft	42	67	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	846	0.01	-4.19	4.20	4.20	208.7
Fwd	43	11	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	860	0.01	-4.26	4.27	4.27	205.3
	44	12	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	866	0.01	-4.29	4.30	4.30	203.8
Bottom	45	21	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	839	0.01	-4.16	4.16	4.16	210.4
	46	22	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	849	0.02	-4.20	4.22	4.21	207.9
	47	31	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	852	0.01	-4.22	4.23	4.23	207.2
Aft	48	32	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	852	0.02	-4.21	4.24	4.23	207.2
Fwd	49	11	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	869	0.00	-4.32	4.30	4.31	203.1
	50	21	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	856	-0.02	-4.27	4.22	4.25	206.2
Side	51	31	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	862	-0.02	-4.30	4.25	4.28	204.8
Aft	52	12	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	860	0.00	-4.27	4.27	4.27	205.1
	53	22	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	847	-0.02	-4.22	4.18	4.20	208.4
	54	32	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	860	0.00	-4.27	4.26	4.27	205.3
Fwd	55	1	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	853	0.00	-4.24	4.22	4.23	207.0
	56	2	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	855	0.00	-4.26	4.22	4.24	206.5
Stern	57	3	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	865	0.01	-4.28	4.30	4.29	204.1
	58	4	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	860	0.00	-4.27	4.26	4.27	205.3
Aft	59	5	2	350	1.5	2.04	10.0	486.0	98000	875	4.34	868	0.02	-4.29	4.32	4.31	203.4

APPENDIX B

INFLUENCE MATRICES FROM FINITE ELEMENT ANALYSIS

Table B-1. Influence Matrix for Bow Panel

Gage	Strains		Kb Matrix												
Chn	(με)		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13
1	e1		0.263	0.06	-0.007	-0.006	-0.006	-0.006	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.0038
2	e2		0.0552	0.2754	0.051	-0.009	-0.008	-0.007	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0013
3	e3	=	-0.001	0.0614	0.2728	-0.025	-0.011	-0.005	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	0.0004
4	e4		0.0245	0.043	0.0539	0.4192	0.1448	0.0318	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0009
5	e5		0.0116	0.0236	0.0347	0.158	0.4072	0.1428	0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0005
6	e6		-5E-05	0.0052	0.0128	0.0397	0.1538	0.4126	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	2E-05
7	e7		0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.263	0.06	-0.007	-0.006	-0.006	-0.006	0.0316
8	e8		0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0552	0.2754	0.051	-0.009	-0.008	-0.007	0.0112
9	e9		0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	-0.001	0.0614	0.2728	-0.025	-0.011	-0.005	0.0036
10	e10		0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0245	0.043	0.0539	0.4192	0.1448	0.0318	0.0075
11	e11		0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0116	0.0236	0.0347	0.158	0.4072	0.1428	0.004
12	e12		0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	-5E-05	0.0052	0.0128	0.0397	0.1538	0.4126	0.0002
13	e13		0.0038	0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.263
14	e14		0.0013	0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0552
15	e15		0.0004	0.0016	0.0045	-3E-04	-2E-04	-1E-04	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	-0.001
16	e16		0.0009	0.0011	0.0011	0.0057	0.0025	0.0008	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0245
17	e17		0.0005	0.0008	0.001	0.0027	0.0067	0.0029	0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0116
18	e18		2E-05	0.0002	0.0005	0.0008	0.0027	0.0062	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	-5E-05
19	e19		0.0005	0.0002	6E-06	-1E-05	-2E-05	-2E-05	0.0038	0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0316
20	e20		0.0002	0.0006	0.0002	-1E-05	-2E-05	-3E-05	0.0013	0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0112
21	e21		5E-05	0.0002	0.0006	-4E-05	-3E-05	-2E-05	0.0004	0.0016	0.0045	-3E-04	-2E-04	-1E-04	0.0036
22	e22		0.0001	0.0002	0.0001	0.0007	0.0003	1E-04	0.0009	0.0011	0.0011	0.0057	0.0025	0.0008	0.0075
23	e23		6E-05	0.0001	0.0001	0.0003	0.0009	0.0003	0.0005	0.0008	0.001	0.0027	0.0067	0.0029	0.004
24	e24		3E-06	3E-05	6E-05	1E-04	0.0003	0.0008	2E-05	0.0002	0.0005	0.0008	0.0027	0.0062	0.0002
25	e25		5E-05	2E-05	7E-07	-1E-06	-3E-06	-3E-06	0.0005	0.0002	6E-06	-1E-05	-2E-05	-2E-05	0.0038
26	e26		2E-05	9E-05	2E-05	-1E-06	-3E-06	-4E-06	0.0002	0.0006	0.0002	-1E-05	-2E-05	-3E-05	0.0013
27	e27		6E-06	3E-05	7E-05	-4E-06	-3E-06	-2E-06	5E-05	0.0002	0.0006	-4E-05	-3E-05	-2E-05	0.0004
28	e28		1E-05	2E-05	2E-05	8E-05	4E-05	1E-05	0.0001	0.0002	0.0001	0.0007	0.0003	1E-04	0.0009
29	e29		7E-06	1E-05	2E-05	4E-05	0.0001	4E-05	6E-05	0.0001	0.0001	0.0003	0.0009	0.0003	0.0005
30	e30		3E-07	4E-06	8E-06	1E-05	4E-05	9E-05	3E-06	3E-05	6E-05	1E-04	0.0003	0.0008	2E-05
31	e31		7E-06	3E-06	9E-08	-1E-07	-4E-07	-4E-07	5E-05	2E-05	7E-07	-1E-06	-3E-06	-3E-06	0.0005
32	e32		2E-06	1E-05	3E-06	-1E-07	-4E-07	-4E-07	2E-05	9E-05	2E-05	-1E-06	-3E-06	-4E-06	0.0002
33	e33		8E-07	4E-06	9E-06	-5E-07	-4E-07	-2E-07	6E-06	3E-05	7E-05	-4E-06	-3E-06	-2E-06	5E-05
34	e34		2E-06	3E-06	2E-06	9E-06	5E-06	1E-06	1E-05	2E-05	2E-05	8E-05	4E-05	1E-05	0.0001
35	e35		8E-07	2E-06	2E-06	4E-06	1E-05	5E-06	7E-06	1E-05	2E-05	4E-05	0.0001	4E-05	6E-05
36	e36		4E-08	6E-07	1E-06	1E-06	6E-06	1E-05	3E-07	4E-06	8E-06	1E-05	4E-05	9E-05	3E-06
37	e37		8E-07	4E-07	1E-08	-2E-08	-5E-08	-5E-08	7E-06	3E-06	9E-08	-1E-07	-4E-07	-4E-07	5E-05
38	e38		3E-07	2E-06	4E-07	-2E-08	-5E-08	-5E-08	2E-06	1E-05	3E-06	-1E-07	-4E-07	-4E-07	2E-05
39	e39		9E-08	5E-07	1E-06	-6E-08	-5E-08	-3E-08	8E-07	4E-06	9E-06	-5E-07	-4E-07	-2E-07	6E-06
40	e40		2E-07	4E-07	3E-07	1E-06	7E-07	2E-07	2E-06	3E-06	2E-06	9E-06	5E-06	1E-06	1E-05
41	e41		1E-07	2E-07	3E-07	5E-07	2E-06	6E-07	8E-07	2E-06	2E-06	4E-06	1E-05	5E-06	7E-06
42	e42		5E-09	8E-08	1E-07	2E-07	7E-07	1E-06	4E-08	6E-07	1E-06	1E-06	6E-06	1E-05	3E-07

Table B-1. Influence Matrix for Bow Panel (Continued)

Kb Matrix															
Col 14	Col 15	Col 16	Col 17	Col 18	Col 19	Col 20	Col 21	Col 22	Col 23	Col 24	Col 25	Col 26	Col 27	Col 28	Col 29
0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0005	0.0002	6E-06	-1E-05	-2E-05	-2E-05	5E-05	2E-05	7E-07	-1E-06	-3E-06
0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0002	0.0006	0.0002	-1E-05	-2E-05	-3E-05	2E-05	9E-05	2E-05	-1E-06	-3E-06
0.0016	0.0045	-3E-04	-2E-04	-1E-04	5E-05	0.0002	0.0006	-4E-05	-3E-05	-2E-05	6E-06	3E-05	7E-05	-4E-06	-3E-06
0.0011	0.0011	0.0057	0.0025	0.0008	0.0001	0.0002	0.0001	0.0007	0.0003	1E-04	1E-05	2E-05	2E-05	8E-05	4E-05
0.0008	0.001	0.0027	0.0067	0.0029	6E-05	0.0001	0.0001	0.0003	0.0009	0.0003	7E-06	1E-05	2E-05	4E-05	0.0001
0.0002	0.0005	0.0008	0.0027	0.0062	3E-06	3E-05	6E-05	1E-04	0.0003	0.0008	3E-07	4E-06	8E-06	1E-05	4E-05
0.0098	0.0003	-8E-04	-0.001	-0.002	0.0038	0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0005	0.0002	6E-06	-1E-05	-2E-05
0.0366	0.0107	-7E-04	-0.001	-0.002	0.0013	0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0002	0.0006	0.0002	-1E-05	-2E-05
0.0122	0.0349	-0.003	-0.002	-0.001	0.0004	0.0016	0.0045	-3E-04	-2E-04	-1E-04	5E-05	0.0002	0.0006	-4E-05	-3E-05
0.0085	0.0084	0.0491	0.0192	0.0065	0.0009	0.0011	0.0011	0.0057	0.0025	0.0008	0.0001	0.0002	0.0001	0.0007	0.0003
0.0057	0.0075	0.0232	0.0522	0.0234	0.0005	0.0008	0.001	0.0027	0.0067	0.0029	6E-05	0.0001	0.0001	0.0003	0.0009
0.0018	0.0038	0.0072	0.0211	0.0504	2E-05	0.0002	0.0005	0.0008	0.0027	0.0062	3E-06	3E-05	6E-05	1E-04	0.0003
0.06	-0.007	-0.006	-0.006	-0.006	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.0038	0.0013	4E-05	-9E-05	-2E-04
0.2754	0.051	-0.009	-0.008	-0.007	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0013	0.0049	0.0014	-9E-05	-2E-04
0.0614	0.2728	-0.025	-0.011	-0.005	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	0.0004	0.0016	0.0045	-3E-04	-2E-04
0.043	0.0539	0.4192	0.1448	0.0318	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0009	0.0011	0.0011	0.0057	0.0025
0.0236	0.0347	0.158	0.4072	0.1428	0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0005	0.0008	0.001	0.0027	0.0067
0.0052	0.0128	0.0397	0.1538	0.4126	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	2E-05	0.0002	0.0005	0.0008	0.0027
0.0098	0.0003	-8E-04	-0.001	-0.002	0.263	0.06	-0.007	-0.006	-0.006	-0.006	0.0316	0.0098	0.0003	-8E-04	-0.001
0.0366	0.0107	-7E-04	-0.001	-0.002	0.0552	0.2754	0.051	-0.009	-0.008	-0.007	0.0112	0.0366	0.0107	-7E-04	-0.001
0.0122	0.0349	-0.003	-0.002	-0.001	-0.001	0.0614	0.2728	-0.025	-0.011	-0.005	0.0036	0.0122	0.0349	-0.003	-0.002
0.0085	0.0084	0.0491	0.0192	0.0065	0.0245	0.043	0.0539	0.4192	0.1448	0.0318	0.0075	0.0085	0.0084	0.0491	0.0192
0.0057	0.0075	0.0232	0.0522	0.0234	0.0116	0.0236	0.0347	0.158	0.4072	0.1428	0.004	0.0057	0.0075	0.0232	0.0522
0.0018	0.0038	0.0072	0.0211	0.0504	-5E-05	0.0052	0.0128	0.0397	0.1538	0.4126	0.0002	0.0018	0.0038	0.0072	0.0211
0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.263	0.06	-0.007	-0.006	-0.006
0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0552	0.2754	0.051	-0.009	-0.008
0.0016	0.0045	-3E-04	-2E-04	-1E-04	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	-0.001	0.0614	0.2728	-0.025	-0.011
0.0011	0.0011	0.0057	0.0025	0.0008	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0245	0.043	0.0539	0.4192	0.1448
0.0008	0.001	0.0027	0.0067	0.0029	0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0116	0.0236	0.0347	0.158	0.4072
0.0002	0.0005	0.0008	0.0027	0.0062	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	-5E-05	0.0052	0.0128	0.0397	0.1538
0.0002	6E-06	-1E-05	-2E-05	-2E-05	0.0038	0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0316	0.0098	0.0003	-8E-04	-0.001
0.0006	0.0002	-1E-05	-2E-05	-3E-05	0.0013	0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0112	0.0366	0.0107	-7E-04	-0.001
0.0002	0.0006	-4E-05	-3E-05	-2E-05	0.0004	0.0016	0.0045	-3E-04	-2E-04	-1E-04	0.0036	0.0122	0.0349	-0.003	-0.002
0.0002	0.0001	0.0007	0.0003	1E-04	0.0009	0.0011	0.0011	0.0057	0.0025	0.0008	0.0075	0.0085	0.0084	0.0491	0.0192
0.0001	0.0001	0.0003	0.0009	0.0003	0.0005	0.0008	0.001	0.0027	0.0067	0.0029	0.004	0.0057	0.0075	0.0232	0.0522
3E-05	6E-05	1E-04	0.0003	0.0008	2E-05	0.0002	0.0005	0.0008	0.0027	0.0062	0.0002	0.0018	0.0038	0.0072	0.0211
2E-05	7E-07	-1E-06	-3E-06	-3E-06	0.0005	0.0002	6E-06	-1E-05	-2E-05	-2E-05	0.0038	0.0013	4E-05	-9E-05	-2E-04
9E-05	2E-05	-1E-06	-3E-06	-4E-06	0.0002	0.0006	0.0002	-1E-05	-2E-05	-3E-05	0.0013	0.0049	0.0014	-9E-05	-2E-04
3E-05	7E-05	-4E-06	-3E-06	-2E-06	5E-05	0.0002	0.0006	-4E-05	-3E-05	-2E-05	0.0004	0.0016	0.0045	-3E-04	-2E-04
2E-05	2E-05	8E-05	4E-05	1E-05	0.0001	0.0002	0.0001	0.0007	0.0003	1E-04	0.0009	0.0011	0.0011	0.0057	0.0025
1E-05	2E-05	4E-05	0.0001	4E-05	6E-05	0.0001	0.0001	0.0003	0.0009	0.0003	0.0005	0.0008	0.001	0.0027	0.0067
4E-06	8E-06	1E-05	4E-05	9E-05	3E-06	3E-05	6E-05	1E-04	0.0003	0.0008	2E-05	0.0002	0.0005	0.0008	0.0027

Table B-1. Influence Matrix for Bow Panel (Concluded)

Kb Matrix														Pres.
Col 30	Col 31	Col 32	Col 33	Col 34	Col 35	Col 36	Col 37	Col 38	Col 39	Col 40	Col 41	Col 42		(psi)
-3E-06	7E-06	3E-06	9E-08	-1E-07	-4E-07	-4E-07	8E-07	4E-07	1E-08	-2E-08	-5E-08	-5E-08		1
-4E-06	2E-06	1E-05	3E-06	-1E-07	-4E-07	-4E-07	3E-07	2E-06	4E-07	-2E-08	-5E-08	-5E-08		1
-2E-06	8E-07	4E-06	9E-06	-5E-07	-4E-07	-2E-07	9E-08	5E-07	1E-06	-6E-08	-5E-08	-3E-08	x	1
1E-05	2E-06	3E-06	2E-06	9E-06	5E-06	1E-06	2E-07	4E-07	3E-07	1E-06	7E-07	2E-07		1
4E-05	8E-07	2E-06	2E-06	4E-06	1E-05	5E-06	1E-07	2E-07	3E-07	5E-07	2E-06	6E-07		1
9E-05	4E-08	6E-07	1E-06	1E-06	6E-06	1E-05	5E-09	8E-08	1E-07	2E-07	7E-07	1E-06		1
-2E-05	5E-05	2E-05	7E-07	-1E-06	-3E-06	-3E-06	7E-06	3E-06	9E-08	-1E-07	-4E-07	-4E-07		1
-3E-05	2E-05	9E-05	2E-05	-1E-06	-3E-06	-4E-06	2E-06	1E-05	3E-06	-1E-07	-4E-07	-4E-07		1
-2E-05	6E-06	3E-05	7E-05	-4E-06	-3E-06	-2E-06	8E-07	4E-06	9E-06	-5E-07	-4E-07	-2E-07		1
1E-04	1E-05	2E-05	2E-05	8E-05	4E-05	1E-05	2E-06	3E-06	2E-06	9E-06	5E-06	1E-06		1
0.0003	7E-06	1E-05	2E-05	4E-05	0.0001	4E-05	8E-07	2E-06	2E-06	4E-06	1E-05	5E-06		1
0.0008	3E-07	4E-06	8E-06	1E-05	4E-05	9E-05	4E-08	6E-07	1E-06	1E-06	6E-06	1E-05		1
-2E-04	0.0005	0.0002	6E-06	-1E-05	-2E-05	-2E-05	5E-05	2E-05	7E-07	-1E-06	-3E-06	-3E-06		1
-2E-04	0.0002	0.0006	0.0002	-1E-05	-2E-05	-3E-05	2E-05	9E-05	2E-05	-1E-06	-3E-06	-4E-06		1
-1E-04	5E-05	0.0002	0.0006	-4E-05	-3E-05	-2E-05	6E-06	3E-05	7E-05	-4E-06	-3E-06	-2E-06		1
0.0008	0.0001	0.0002	0.0001	0.0007	0.0003	1E-04	1E-05	2E-05	2E-05	8E-05	4E-05	1E-05		1
0.0029	6E-05	0.0001	0.0001	0.0003	0.0009	0.0003	7E-06	1E-05	2E-05	4E-05	0.0001	4E-05		1
0.0062	3E-06	3E-05	6E-05	1E-04	0.0003	0.0008	3E-07	4E-06	8E-06	1E-05	4E-05	9E-05		1
-0.002	0.0038	0.0013	4E-05	-9E-05	-2E-04	-2E-04	0.0005	0.0002	6E-06	-1E-05	-2E-05	-2E-05		1
-0.002	0.0013	0.0049	0.0014	-9E-05	-2E-04	-2E-04	0.0002	0.0006	0.0002	-1E-05	-2E-05	-3E-05		1
-0.001	0.0004	0.0016	0.0045	-3E-04	-2E-04	-1E-04	5E-05	0.0002	0.0006	-4E-05	-3E-05	-2E-05		1
0.0065	0.0009	0.0011	0.0011	0.0057	0.0025	0.0008	0.0001	0.0002	0.0001	0.0007	0.0003	1E-04		1
0.0234	0.0005	0.0008	0.001	0.0027	0.0067	0.0029	6E-05	0.0001	0.0001	0.0003	0.0009	0.0003		1
0.0504	2E-05	0.0002	0.0005	0.0008	0.0027	0.0062	3E-06	3E-05	6E-05	1E-04	0.0003	0.0008		1
-0.006	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.0038	0.0013	4E-05	-9E-05	-2E-04	-2E-04		1
-0.007	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0013	0.0049	0.0014	-9E-05	-2E-04	-2E-04		1
-0.005	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	0.0004	0.0016	0.0045	-3E-04	-2E-04	-1E-04		1
0.0318	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0009	0.0011	0.0011	0.0057	0.0025	0.0008		1
0.1428	0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0005	0.0008	0.001	0.0027	0.0067	0.0029		1
0.4126	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	2E-05	0.0002	0.0005	0.0008	0.0027	0.0062		1
-0.002	0.263	0.06	-0.007	-0.006	-0.006	-0.006	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002		1
-0.002	0.0552	0.2754	0.051	-0.009	-0.008	-0.007	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002		1
-0.001	-0.001	0.0614	0.2728	-0.025	-0.011	-0.005	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001		1
0.0065	0.0245	0.043	0.0539	0.4192	0.1448	0.0318	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065		1
0.0234	0.0116	0.0236	0.0347	0.158	0.4072	0.1428	0.004	0.0057	0.0075	0.0232	0.0522	0.0234		1
0.0504	-5E-05	0.0052	0.0128	0.0397	0.1538	0.4126	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504		1
-2E-04	0.0316	0.0098	0.0003	-8E-04	-0.001	-0.002	0.263	0.06	-0.007	-0.006	-0.006	-0.006		1
-2E-04	0.0112	0.0366	0.0107	-7E-04	-0.001	-0.002	0.0552	0.2754	0.051	-0.009	-0.008	-0.007		1
-1E-04	0.0036	0.0122	0.0349	-0.003	-0.002	-0.001	-0.001	0.0614	0.2728	-0.025	-0.011	-0.005		1
0.0008	0.0075	0.0085	0.0084	0.0491	0.0192	0.0065	0.0245	0.043	0.0539	0.4192	0.1448	0.0318		1
0.0029	0.004	0.0057	0.0075	0.0232	0.0522	0.0234	0.0116	0.0236	0.0347	0.158	0.4072	0.1428		1
0.0062	0.0002	0.0018	0.0038	0.0072	0.0211	0.0504	-5E-05	0.0052	0.0128	0.0397	0.1538	0.4126		1

Table B-2. Influence Matrix for Bottom Panel

Gage Chn	Strains (με)		Kf Matrix Col 1	Col 2	Col 3	Col 4	Col 5	Col 6		Pres. (psi)
43	e1		0.3028	0.0499	-0.012	-0.002	0.0005	8E-05		1
44	e2		0.0478	0.3004	-0.002	-0.012	7E-05	0.0005		1
45	e3	=	-0.012	-0.002	0.3028	0.0499	-0.012	-0.002	x	1
46	e4		-0.002	-0.012	0.0478	0.3004	-0.002	-0.012		1
47	e5		0.0005	8E-05	-0.012	-0.002	0.3028	0.0499		1
48	e6		7E-05	0.0005	-0.002	-0.012	0.0478	0.3004		1

Table B-3. Influence Matrix for Side Panel

Gage Chn	Strains (με)		Ks Matrix Col 1	Col 2	Col 3	Col 4	Col 5	Col 6		Pres. (psi)
49	e1		0.3232	0.0564	-0.017	0.0333	0.0099	-0.003		1
50	e2		0.1118	0.3608	0.07	0.0187	0.0396	0.0134		1
51	e3	=	0.106	0.1914	0.431	0.0141	0.0276	0.0468	x	1
52	e4		0.0333	0.0099	-0.003	0.3232	0.0564	-0.017		1
53	e5		0.0187	0.0396	0.0134	0.1118	0.3608	0.07		1
54	e6		0.0141	0.0276	0.0468	0.106	0.1914	0.431		1

Table B-4. Influence Matrix for Transom Panel

Gage	Strains		Kt Matrix						Pres.
Chn	($\mu\varepsilon$)		Col 1	Col 2	Col 3	Col 4	Col 5		(psi)
55	e1		0.4792	0.2654	0.1611	0.1297	0.0959		1
56	e2		0.1416	0.4994	0.237	0.1076	0.0796		1
57	e3	=	-0.011	0.1176	0.4206	0.1416	0.0964	x	1
58	e4		-0.014	-0.042	-0.081	0.4214	0.2846		1
59	e5		-0.002	-0.003	-0.006	0.0866	0.4268		1

APPENDIX C

DATA REDUCTION MATRICES

Table C-1. Data Reduction Matrix for Bow Panel

Gage Chn	Pres. (psi)		(Kb Matrix)^-1 Col 1	Col 2	Col 3	Col 4	Col 5	Col 6	Col 7	Col 8	Col 9	Col 10	Col 11	Col 12	Col 13
1	p1		4.0502	-0.942	0.2636	0.0384	0.0224	0.0302	-0.467	0.076	-0.029	-0.005	-8E-04	0.0024	-0.002
2	p2		-0.84	4.0424	-0.769	0.0185	0.0219	0.0338	0.0413	-0.489	0.0325	-0.011	-0.002	0.0024	0.0093
3	p3	=	0.2063	-0.923	3.8596	0.2018	0.016	0.0168	-0.058	0.0589	-0.472	-0.028	-0.002	-0.003	0.0049
4	p4		-0.16	-0.221	-0.382	2.7711	-1.055	0.1416	-0.009	0.0181	0.0432	-0.309	0.1132	-0.019	0.0032
5	p5		-0.028	-0.045	-0.131	-1.143	3.2917	-1.044	-0.003	0.0014	0.0018	0.1048	-0.383	0.0825	0.0015
6	p6		0.0308	0.0175	-0.02	0.1557	-1.123	2.834	0.0034	-0.003	-0.008	-0.019	0.1186	-0.324	-6E-04
7	p7		-0.467	0.0761	-0.029	-0.005	-8E-04	0.0024	4.1046	-0.946	0.2672	0.039	0.0222	0.0291	-0.467
8	p8		0.0412	-0.489	0.0324	-0.011	-0.002	0.0025	-0.837	4.1031	-0.765	0.0208	0.0219	0.0326	0.04
9	p9		-0.058	0.0589	-0.472	-0.028	-0.002	-0.003	0.2182	-0.923	3.9183	0.2057	0.0163	0.017	-0.058
10	p10		-0.009	0.0182	0.0432	-0.309	0.1132	-0.019	-0.156	-0.222	-0.386	2.8057	-1.067	0.144	-0.009
11	p11		-0.003	0.0015	0.0018	0.1048	-0.383	0.0825	-0.026	-0.044	-0.129	-1.152	3.3367	-1.049	-0.003
12	p12		0.0034	-0.003	-0.008	-0.019	0.1187	-0.324	0.0298	0.0182	-0.018	0.1582	-1.135	2.8713	0.0035
13	p13		-0.002	0.004	0.0002	5E-05	-2E-04	-8E-04	-0.467	0.0756	-0.029	-0.005	-8E-04	0.0025	4.1046
14	p14		0.0093	-0.005	0.0085	0.001	-2E-04	-1E-03	0.04	-0.489	0.0314	-0.011	-0.002	0.0026	-0.837
15	p15		0.0049	0.007	-0.002	0.0003	4E-06	-1E-04	-0.058	0.058	-0.472	-0.028	-0.002	-0.002	0.2182
16	p16		0.0032	0.001	0.0004	-0.002	0.0011	0.0002	-0.009	0.018	0.0431	-0.309	0.1131	-0.019	-0.156
17	p17		0.0015	0.0009	0.0022	0.0051	-0.004	0.0061	-0.003	0.0013	0.0015	0.1042	-0.383	0.0818	-0.026
18	p18		-6E-04	0.0002	0.0012	0.0002	0.002	-0.002	0.0035	-0.003	-0.008	-0.019	0.1184	-0.324	0.0298
19	p19		-8E-05	4E-05	-6E-05	-3E-07	-3E-07	9E-06	-0.002	0.004	0.0002	5E-05	-2E-04	-8E-04	-0.467
20	p20		-2E-05	-2E-04	7E-05	7E-06	3E-06	1E-05	0.0093	-0.005	0.0085	0.001	-2E-04	-1E-03	0.04
21	p21		-1E-04	5E-05	-1E-04	-2E-05	6E-06	2E-05	0.0049	0.007	-0.002	0.0004	3E-06	-1E-04	-0.058
22	p22		-4E-06	-1E-05	-3E-05	-2E-05	1E-05	2E-06	0.0032	0.001	0.0004	-0.002	0.0011	0.0002	-0.009
23	p23		-9E-05	-5E-05	-4E-05	2E-05	-6E-05	6E-05	0.0015	0.0009	0.0022	0.0051	-0.004	0.0061	-0.003
24	p24		-4E-05	-2E-05	-3E-06	-2E-05	3E-05	-4E-05	-6E-04	0.0002	0.0012	0.0002	0.002	-0.002	0.0035
25	p25		-3E-07	2E-06	-7E-07	-5E-08	-4E-08	-1E-07	-8E-05	4E-05	-6E-05	-3E-07	-2E-07	9E-06	-0.002
26	p26		3E-06	-3E-06	4E-06	3E-07	-5E-08	-6E-07	-2E-05	-2E-04	7E-05	7E-06	3E-06	1E-05	0.0093
27	p27		9E-07	3E-06	-9E-07	-1E-07	-4E-08	-2E-07	-1E-04	5E-05	-1E-04	-2E-05	6E-06	2E-05	0.0049
28	p28		9E-07	4E-07	2E-07	-1E-07	1E-07	-1E-07	-4E-06	-1E-05	-3E-05	-2E-05	1E-05	2E-06	0.0032
29	p29		1E-06	7E-07	1E-06	7E-07	-8E-07	6E-07	-9E-05	-5E-05	-4E-05	2E-05	-6E-05	6E-05	0.0015
30	p30		3E-07	2E-07	5E-07	-1E-07	3E-07	-5E-07	-4E-05	-2E-05	-3E-06	-2E-05	3E-05	-4E-05	-6E-04
31	p31		-2E-08	2E-08	-3E-08	-1E-09	-6E-10	4E-09	-3E-07	2E-06	-7E-07	-5E-08	-4E-08	-1E-07	-8E-05
32	p32		5E-09	-9E-08	5E-08	7E-09	-4E-10	3E-09	3E-06	-3E-06	4E-06	3E-07	-5E-08	-6E-07	-2E-05
33	p33		-4E-08	3E-08	-5E-08	-5E-09	2E-09	1E-08	9E-07	3E-06	-9E-07	-1E-07	-4E-08	-2E-07	-1E-04
34	p34		-7E-09	-5E-09	-8E-09	-2E-09	5E-09	2E-10	9E-07	4E-07	2E-07	-1E-07	1E-07	-1E-07	-4E-06
35	p35		-3E-08	-2E-08	-1E-08	9E-09	-2E-08	2E-08	1E-06	7E-07	1E-06	7E-07	-8E-07	6E-07	-9E-05
36	p36		-1E-08	-7E-09	-3E-09	-4E-09	8E-09	-4E-09	3E-07	2E-07	5E-07	-1E-07	3E-07	-5E-07	-4E-05
37	p37		6E-11	5E-10	-3E-10	-1E-10	1E-10	-9E-12	-2E-08	2E-08	-3E-08	-1E-09	-6E-10	4E-09	-3E-07
38	p38		1E-09	-1E-09	1E-09	3E-10	-2E-10	-2E-10	5E-09	-9E-08	5E-08	7E-09	-4E-10	3E-09	3E-06
39	p39		1E-10	9E-10	2E-10	-1E-10	2E-10	-3E-10	-4E-08	3E-08	-5E-08	-5E-09	2E-09	1E-08	9E-07
40	p40		2E-10	4E-10	-2E-10	-2E-11	-8E-11	3E-11	-7E-09	-5E-09	-8E-09	-2E-09	5E-09	2E-10	9E-07
41	p41		6E-10	9E-12	4E-10	4E-11	3E-10	1E-10	-3E-08	-2E-08	-1E-08	9E-09	-2E-08	2E-08	1E-06
42	p42		1E-10	9E-11	2E-10	-1E-10	1E-10	-5E-10	-1E-08	-7E-09	-3E-09	-4E-09	8E-09	-4E-09	3E-07

Table C-1. Data Reduction Matrix for Bow Panel (Continued)

(Kb Matrix)^-1															
Col 14	Col 15	Col 16	Col 17	Col 18	Col 19	Col 20	Col 21	Col 22	Col 23	Col 24	Col 25	Col 26	Col 27	Col 28	Col 29
0.004	0.0002	5E-05	-2E-04	-8E-04	-8E-05	4E-05	-6E-05	-3E-07	-3E-07	9E-06	-3E-07	2E-06	-7E-07	-5E-08	-4E-08
-0.005	0.0085	0.001	-2E-04	-1E-03	-2E-05	-2E-04	7E-05	7E-06	3E-06	1E-05	3E-06	-3E-06	4E-06	3E-07	-5E-08
0.007	-0.002	0.0003	4E-06	-1E-04	-1E-04	5E-05	-1E-04	-2E-05	6E-06	2E-05	9E-07	3E-06	-9E-07	-1E-07	-4E-08
0.001	0.0004	-0.002	0.0011	0.0002	-4E-06	-1E-05	-3E-05	-2E-05	1E-05	2E-06	9E-07	4E-07	2E-07	-1E-07	1E-07
0.0009	0.0022	0.0051	-0.004	0.0061	-9E-05	-5E-05	-4E-05	2E-05	-6E-05	6E-05	1E-06	7E-07	1E-06	7E-07	-8E-07
0.0002	0.0012	0.0002	0.002	-0.002	-4E-05	-2E-05	-3E-06	-2E-05	3E-05	-4E-05	3E-07	2E-07	5E-07	-1E-07	3E-07
0.0756	-0.029	-0.005	-8E-04	0.0025	-0.002	0.004	0.0002	5E-05	-2E-04	-8E-04	-8E-05	4E-05	-6E-05	-3E-07	-2E-07
-0.489	0.0314	-0.011	-0.002	0.0026	0.0093	-0.005	0.0085	0.001	-2E-04	-1E-03	-2E-05	-2E-04	7E-05	7E-06	3E-06
0.058	-0.472	-0.028	-0.002	-0.002	0.0049	0.007	-0.002	0.0004	3E-06	-1E-04	-1E-04	5E-05	-1E-04	-2E-05	6E-06
0.018	0.0431	-0.309	0.1131	-0.019	0.0032	0.001	0.0004	-0.002	0.0011	0.0002	-4E-06	-1E-05	-3E-05	-2E-05	1E-05
0.0013	0.0015	0.1042	-0.383	0.0818	0.0015	0.0009	0.0022	0.0051	-0.004	0.0061	-9E-05	-5E-05	-4E-05	2E-05	-6E-05
-0.003	-0.008	-0.019	0.1184	-0.324	-6E-04	0.0002	0.0012	0.0002	0.002	-0.002	-4E-05	-2E-05	-3E-06	-2E-05	3E-05
-0.946	0.2672	0.039	0.0222	0.0291	-0.467	0.0756	-0.029	-0.005	-8E-04	0.0025	-0.002	0.004	0.0002	5E-05	-2E-04
4.1031	-0.765	0.0208	0.0219	0.0326	0.04	-0.489	0.0314	-0.011	-0.002	0.0026	0.0093	-0.005	0.0085	0.001	-2E-04
-0.923	3.9183	0.2057	0.0163	0.017	-0.058	0.058	-0.472	-0.028	-0.002	-0.002	0.0049	0.007	-0.002	0.0004	3E-06
-0.222	-0.386	2.8057	-1.067	0.144	-0.009	0.018	0.0431	-0.309	0.1131	-0.019	0.0032	0.001	0.0004	-0.002	0.0011
-0.044	-0.129	-1.152	3.3367	-1.049	-0.003	0.0013	0.0015	0.1042	-0.383	0.0818	0.0015	0.0009	0.0022	0.0051	-0.004
0.0182	-0.018	0.1582	-1.135	2.8713	0.0035	-0.003	-0.008	-0.019	0.1184	-0.324	-6E-04	0.0002	0.0012	0.0002	0.002
0.0756	-0.029	-0.005	-8E-04	0.0025	4.1046	-0.946	0.2672	0.039	0.0222	0.0291	-0.467	0.0756	-0.029	-0.005	-8E-04
-0.489	0.0314	-0.011	-0.002	0.0026	-0.837	4.1031	-0.765	0.0208	0.0219	0.0326	0.04	-0.489	0.0314	-0.011	-0.002
0.058	-0.472	-0.028	-0.002	-0.002	0.2182	-0.923	3.9183	0.2057	0.0163	0.017	-0.058	0.058	-0.472	-0.028	-0.002
0.018	0.0431	-0.309	0.1131	-0.019	-0.156	-0.222	-0.386	2.8057	-1.067	0.144	-0.009	0.018	0.0431	-0.309	0.1131
0.0013	0.0015	0.1042	-0.383	0.0818	-0.026	-0.044	-0.129	-1.152	3.3367	-1.049	-0.003	0.0013	0.0015	0.1042	-0.383
-0.003	-0.008	-0.019	0.1184	-0.324	0.0298	0.0182	-0.018	0.1582	-1.135	2.8713	0.0035	-0.003	-0.008	-0.019	0.1184
0.004	0.0002	5E-05	-2E-04	-8E-04	-0.467	0.0756	-0.029	-0.005	-8E-04	0.0025	4.1046	-0.946	0.2672	0.039	0.0222
-0.005	0.0085	0.001	-2E-04	-1E-03	0.04	-0.489	0.0314	-0.011	-0.002	0.0026	-0.837	4.1031	-0.765	0.0208	0.0219
0.007	-0.002	0.0004	3E-06	-1E-04	-0.058	0.058	-0.472	-0.028	-0.002	-0.002	0.2182	-0.923	3.9183	0.2057	0.0163
0.001	0.0004	-0.002	0.0011	0.0002	-0.009	0.018	0.0431	-0.309	0.1131	-0.019	-0.156	-0.222	-0.386	2.8057	-1.067
0.0009	0.0022	0.0051	-0.004	0.0061	-0.003	0.0013	0.0015	0.1042	-0.383	0.0818	-0.026	-0.044	-0.129	-1.152	3.3367
0.0002	0.0012	0.0002	0.002	-0.002	0.0035	-0.003	-0.008	-0.019	0.1184	-0.324	0.0298	0.0182	-0.018	0.1582	-1.135
4E-05	-6E-05	-3E-07	-2E-07	9E-06	-0.002	0.004	0.0002	5E-05	-2E-04	-8E-04	-0.467	0.0756	-0.029	-0.005	-8E-04
-2E-04	7E-05	7E-06	3E-06	1E-05	0.0093	-0.005	0.0085	0.001	-2E-04	-1E-03	0.04	-0.489	0.0314	-0.011	-0.002
5E-05	-1E-04	-2E-05	6E-06	2E-05	0.0049	0.007	-0.002	0.0004	3E-06	-1E-04	-0.058	0.058	-0.472	-0.028	-0.002
-1E-05	-3E-05	-2E-05	1E-05	2E-06	0.0032	0.001	0.0004	-0.002	0.0011	0.0002	-0.009	0.018	0.0431	-0.309	0.1131
-5E-05	-4E-05	2E-05	-6E-05	6E-05	0.0015	0.0009	0.0022	0.0051	-0.004	0.0061	-0.003	0.0013	0.0015	0.1042	-0.383
-2E-05	-3E-06	-2E-05	3E-05	-4E-05	-6E-04	0.0002	0.0012	0.0002	0.002	-0.002	0.0035	-0.003	-0.008	-0.019	0.1184
2E-06	-7E-07	-5E-08	-4E-08	-1E-07	-8E-05	4E-05	-6E-05	-3E-07	-3E-07	9E-06	-0.002	0.004	0.0002	5E-05	-2E-04
-3E-06	4E-06	3E-07	-5E-08	-6E-07	-2E-05	-2E-04	7E-05	7E-06	3E-06	1E-05	0.0093	-0.005	0.0085	0.001	-2E-04
3E-06	-9E-07	-1E-07	-4E-08	-2E-07	-1E-04	5E-05	-1E-04	-2E-05	6E-06	2E-05	0.0049	0.007	-0.002	0.0003	4E-06
4E-07	2E-07	-1E-07	1E-07	-1E-07	-4E-06	-1E-05	-3E-05	-2E-05	1E-05	2E-06	0.0032	0.001	0.0004	-0.002	0.0011
7E-07	1E-06	7E-07	-8E-07	6E-07	-9E-05	-5E-05	-4E-05	2E-05	-6E-05	6E-05	0.0015	0.0009	0.0022	0.0051	-0.004
2E-07	5E-07	-1E-07	3E-07	-5E-07	-4E-05	-2E-05	-3E-06	-2E-05	3E-05	-4E-05	-6E-04	0.0002	0.0012	0.0002	0.002

Table C-1. Data Reduction Matrix for Bow Panel (Concluded)

(Kb Matrix)^-1														Strains
Col 30	Col 31	Col 32	Col 33	Col 34	Col 35	Col 36	Col 37	Col 38	Col 39	Col 40	Col 41	Col 42		(με)
-1E-07	-2E-08	2E-08	-3E-08	-1E-09	-6E-10	4E-09	6E-11	5E-10	-3E-10	-1E-10	1E-10	-9E-12		e1
-6E-07	5E-09	-9E-08	5E-08	7E-09	-4E-10	3E-09	1E-09	-1E-09	1E-09	3E-10	-2E-10	-2E-10		e2
-2E-07	-4E-08	3E-08	-5E-08	-5E-09	2E-09	1E-08	1E-10	9E-10	2E-10	-1E-10	2E-10	-3E-10	x	e3
-1E-07	-7E-09	-5E-09	-8E-09	-2E-09	5E-09	2E-10	2E-10	4E-10	-2E-10	-2E-11	-8E-11	3E-11		e4
6E-07	-3E-08	-2E-08	-1E-08	9E-09	-2E-08	2E-08	6E-10	9E-12	4E-10	4E-11	3E-10	1E-10		e5
-5E-07	-1E-08	-7E-09	-3E-09	-4E-09	8E-09	-4E-09	1E-10	9E-11	2E-10	-1E-10	1E-10	-5E-10		e6
9E-06	-3E-07	2E-06	-7E-07	-5E-08	-4E-08	-1E-07	-2E-08	2E-08	-3E-08	-1E-09	-6E-10	4E-09		e7
1E-05	3E-06	-3E-06	4E-06	3E-07	-5E-08	-6E-07	5E-09	-9E-08	5E-08	7E-09	-4E-10	3E-09		e8
2E-05	9E-07	3E-06	-9E-07	-1E-07	-4E-08	-2E-07	-4E-08	3E-08	-5E-08	-5E-09	2E-09	1E-08		e9
2E-06	9E-07	4E-07	2E-07	-1E-07	1E-07	-1E-07	-7E-09	-5E-09	-8E-09	-2E-09	5E-09	2E-10		e10
6E-05	1E-06	7E-07	1E-06	7E-07	-8E-07	6E-07	-3E-08	-2E-08	-1E-08	9E-09	-2E-08	2E-08		e11
-4E-05	3E-07	2E-07	5E-07	-1E-07	3E-07	-5E-07	-1E-08	-7E-09	-3E-09	-4E-09	8E-09	-4E-09		e12
-8E-04	-8E-05	4E-05	-6E-05	-3E-07	-2E-07	9E-06	-3E-07	2E-06	-7E-07	-5E-08	-4E-08	-1E-07		e13
-1E-03	-2E-05	-2E-04	7E-05	7E-06	3E-06	1E-05	3E-06	-3E-06	4E-06	3E-07	-5E-08	-6E-07		e14
-1E-04	-1E-04	5E-05	-1E-04	-2E-05	6E-06	2E-05	9E-07	3E-06	-9E-07	-1E-07	-4E-08	-2E-07		e15
0.0002	-4E-06	-1E-05	-3E-05	-2E-05	1E-05	2E-06	9E-07	4E-07	2E-07	-1E-07	1E-07	-1E-07		e16
0.0061	-9E-05	-5E-05	-4E-05	2E-05	-6E-05	6E-05	1E-06	7E-07	1E-06	7E-07	-8E-07	6E-07		e17
-0.002	-4E-05	-2E-05	-3E-06	-2E-05	3E-05	-4E-05	3E-07	2E-07	5E-07	-1E-07	3E-07	-5E-07		e18
0.0025	-0.002	0.004	0.0002	5E-05	-2E-04	-8E-04	-8E-05	4E-05	-6E-05	-3E-07	-3E-07	9E-06		e19
0.0026	0.0093	-0.005	0.0085	0.001	-2E-04	-1E-03	-2E-05	-2E-04	7E-05	7E-06	3E-06	1E-05		e20
-0.002	0.0049	0.007	-0.002	0.0004	3E-06	-1E-04	-1E-04	5E-05	-1E-04	-2E-05	6E-06	2E-05		e21
-0.019	0.0032	0.001	0.0004	-0.002	0.0011	0.0002	-4E-06	-1E-05	-3E-05	-2E-05	1E-05	2E-06		e22
0.0818	0.0015	0.0009	0.0022	0.0051	-0.004	0.0061	-9E-05	-5E-05	-4E-05	2E-05	-6E-05	6E-05		e23
-0.324	-6E-04	0.0002	0.0012	0.0002	0.002	-0.002	-4E-05	-2E-05	-3E-06	-2E-05	3E-05	-4E-05		e24
0.0291	-0.467	0.0756	-0.029	-0.005	-8E-04	0.0025	-0.002	0.004	0.0002	5E-05	-2E-04	-8E-04		e25
0.0326	0.04	-0.489	0.0314	-0.011	-0.002	0.0026	0.0093	-0.005	0.0085	0.001	-2E-04	-1E-03		e26
0.017	-0.058	0.058	-0.472	-0.028	-0.002	-0.002	0.0049	0.007	-0.002	0.0003	4E-06	-1E-04		e27
0.144	-0.009	0.018	0.0431	-0.309	0.1131	-0.019	0.0032	0.001	0.0004	-0.002	0.0011	0.0002		e28
-1.049	-0.003	0.0013	0.0015	0.1042	-0.383	0.0818	0.0015	0.0009	0.0022	0.0051	-0.004	0.0061		e29
2.8713	0.0035	-0.003	-0.008	-0.019	0.1184	-0.324	-6E-04	0.0002	0.0012	0.0002	0.002	-0.002		e30
0.0025	4.1046	-0.946	0.2672	0.039	0.0222	0.0291	-0.467	0.0761	-0.029	-0.005	-8E-04	0.0024		e31
0.0026	-0.837	4.1031	-0.765	0.0208	0.0219	0.0326	0.0412	-0.489	0.0324	-0.011	-0.002	0.0025		e32
-0.002	0.2182	-0.923	3.9183	0.2057	0.0163	0.017	-0.058	0.0589	-0.472	-0.028	-0.002	-0.003		e33
-0.019	-0.156	-0.222	-0.386	2.8057	-1.067	0.144	-0.009	0.0182	0.0432	-0.309	0.1132	-0.019		e34
0.0818	-0.026	-0.044	-0.129	-1.152	3.3367	-1.049	-0.003	0.0015	0.0018	0.1048	-0.383	0.0825		e35
-0.324	0.0298	0.0182	-0.018	0.1582	-1.135	2.8713	0.0034	-0.003	-0.008	-0.019	0.1187	-0.324		e36
-8E-04	-0.467	0.076	-0.029	-0.005	-8E-04	0.0024	4.0502	-0.942	0.2636	0.0384	0.0224	0.0302		e37
-1E-03	0.0413	-0.489	0.0325	-0.011	-0.002	0.0024	-0.84	4.0424	-0.769	0.0185	0.0219	0.0338		e38
-1E-04	-0.058	0.0589	-0.472	-0.028	-0.002	-0.003	0.2063	-0.923	3.8596	0.2018	0.016	0.0168		e39
0.0002	-0.009	0.0181	0.0432	-0.309	0.1132	-0.019	-0.16	-0.221	-0.382	2.7711	-1.055	0.1416		e40
0.0061	-0.003	0.0014	0.0018	0.1048	-0.383	0.0825	-0.028	-0.045	-0.131	-1.143	3.2917	-1.044		e41
-0.002	0.0034	-0.003	-0.008	-0.019	0.1186	-0.324	0.0308	0.0175	-0.02	0.1557	-1.123	2.834		e42

Table C-2. Data Reduction Matrix for Bottom Panel

Gage	Pres.		(Kf Matrix)^-1							Strains
Chn	(psi)		Col 1	Col 2	Col 3	c4	c5	c6		(με)
43	p1		3.394	-0.567	0.1181	-0.039	-0.001	-0.001		e1
44	p2		-0.544	3.4281	-0.037	0.1204	-9E-04	-0.001		e2
45	p3	=	0.1181	-0.039	3.3983	-0.569	0.1181	-0.039	x	e3
46	p4		-0.037	0.1204	-0.546	3.4324	-0.037	0.1204		e4
47	p5		-0.001	-0.001	0.1181	-0.039	3.394	-0.567		e5
48	p6		-9E-04	-0.001	-0.037	0.1204	-0.544	3.4281		e6

Table C-3. Data Reduction Matrix for Side Panel

Gage	Pres.		(Ks Matrix)^-1							Strains
Chn	(psi)		Col 1	Col 2	Col 3	Col 4	Col 5	Col 6		(με)
49	p1		3.2627	-0.634	0.2566	-0.306	0.0214	-0.027		e1
50	p2		-0.926	3.2426	-0.562	0.0283	-0.302	0.0138		e2
51	p3	=	-0.391	-1.271	2.5331	0.0594	0.0769	-0.248	x	e3
52	p4		-0.306	0.0214	-0.027	3.2627	-0.634	0.2566		e4
53	p5		0.0283	-0.302	0.0138	-0.926	3.2426	-0.562		e5
54	p6		0.0594	0.0769	-0.248	-0.391	-1.271	2.5331		e6

Table C-4. Data Reduction Matrix for Transom Panel

Gage	Pres.		(Kt Matrix)^-1						Strains
Chn	(psi)		Col 1	Col 2	Col 3	Col 4	Col 5		(με)
55	p1		2.442	-1.257	-0.29	-0.327	-0.031		e1
56	p2		-0.837	2.7334	-1.224	-0.023	-0.03		e2
57	p3	=	0.2813	-0.822	2.5893	-0.747	0.0037	x	e3
58	p4		0.0523	0.0841	0.4028	2.5777	-1.837		e4
59	p5		-0.002	-0.015	-0.055	-0.535	2.7155		e5

APPENDIX D

SUMMARIES
OF
IMPACT EVENTS BY RECORDING TIME

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
1	15:57:34	28 Aug 92	N2411557.34	-35	34	8	Bow		7	59	X		
2	16:12:02	28 Aug 92	N2411612.02	-32	30	21	Bow	Transom	3	59	X		
3	16:14:56	28 Aug 92	N2411614.56	-32	147	21	Bow		7	59	X		
4	16:22:45	28 Aug 92	N2411622.45	-31	190	21	Bow		7	59	X		Excellent
5	16:28:26	28 Aug 92	N2411628.26	-30	76	56	Side			59			Excel., Trig. by Trans
6	16:30:22	28 Aug 92	N2411630.22	-29	51	32	Bow		7	59	X		
7	16:39:27	28 Aug 92	N2411639.27	-29	127	21	Bow		6	59			
8	16:57:22	28 Aug 92	N2411657.22	-29	90	21	Bow		7	59	X		
9	17:07:50	28 Aug 92	N2411707.50	-29	111	2	Bow		4	59			
10	21:11:46	28 Aug 92	N2412111.46	-24	69	21	Bow		4	59	X		
11	23:54:01	28 Aug 92	N2412354.01	-5	82	2	Bow		3	16	X	Dn1	
12	0:17:39	29 Aug 92	N2420017.39	-3	72	9	Bow		3	16	X	Dn1	
13	0:24:46	29 Aug 92	N2420024.46	-3	77	2	Bow		3	16	X	Dn1	
14	1:27:16	29 Aug 92	N2420127.16	-3	54	3	Bow		3	16	X	Dn1	
15	1:50:55	29 Aug 92	N2420150.55	-3	56	8	Bow		3	16	X	Dn1	
16	2:06:33	29 Aug 92	N2420206.33	-3	65	2	Bow		3	16	X	Dn1	
17	2:24:35	29 Aug 92	N2420224.35	-4	61	2	Bow		3	16	X	Dn1	
18	2:32:27	29 Aug 92	N2420232.27	-5	58	8	Bow		3	16	X	Dn1	
19	2:41:42	29 Aug 92	N2420241.42	-5	133	3	Bow		3	16	X	Dn1	
20	13:22:14	29 Aug 92	N2421322.14	-3	46	14	Bow		3	16	X	Dn1	
21	13:43:37	29 Aug 92	N2421343.37	-1	36	3	Bow		3	16	X	Dn1	
22	13:44:36	29 Aug 92	N2421344.36	-4	124	15	Bow		3	16		Dn1	
23	13:49:02	29 Aug 92	N2421349.02	-4	69	2	Bow		3	16		Dn1	
24	14:20:41	29 Aug 92	N2421420.41	-9	105	8	Bow		4	59	X		
25	14:21:56	29 Aug 92	N2421421.56	-10	35	46	Bottom			59			Drift
26	14:23:20	29 Aug 92	N2421423.20	-12	88	21	Bow		7	59			Long
27	14:25:30	29 Aug 92	N2421425.30	-10	35	46	Bottom			59			Drift
28	14:26:03	29 Aug 92	N2421426.03	-8	35	46	Bottom			59			Drift
29	14:26:47	29 Aug 92	N2421426.47	-8	35	46	Bottom			59			Drift
30	14:27:26	29 Aug 92	N2421427.26	-9	35	46	Bottom			59			Drift
31	14:29:00	29 Aug 92	N2421429.00	-10	35	46	Bow		3	59			Bottom Drift
32	14:30:53	29 Aug 92	N2421430.53	-9	35	46	Bottom			59			Drift
33	16:23:45	29 Aug 92	N2421623.45	-4	54	14	Bow		3	16		Dn1	
34	16:40:28	29 Aug 92	N2421640.28	-5	36	7	Bow		3	16	X	Dn1	
35	2:20:54	30 Aug 92	N2430220.54	-5	51	2	Bow		3	16	X	Dn1	
36	2:31:36	30 Aug 92	N2430231.36	-7	53	3	Bow		3	16	X	Dn1	
37	2:41:24	30 Aug 92	N2430241.24	-6	54	2	Bow		3	16	X	Dn1	
38	2:44:00	30 Aug 92	N2430244.00	-6	34	2	Bow		3	16	X	Dn1	
39	2:48:24	30 Aug 92	N2430248.24	-5	40	3	Bow		3	16	2X	Dn2	Long
40	2:49:48	30 Aug 92	N2430249.48	-6	56	14	Bow		3	16		Dn1	
41	3:29:44	30 Aug 92	N2430329.44	-6	61	2	Bow		3	16	X	Dn1	
42	4:22:07	30 Aug 92	N2430422.07	-7	146	14	Bow		3	16		Dn1	
43	4:37:43	30 Aug 92	N2430437.43	-15	44	27	Bow		7	59	X		
44	4:41:13	30 Aug 92	N2430441.13	-15	131	51	Side			59			Excellent
45	5:05:18	30 Aug 92	N2430505.18	-15	41	2	Bow	Side	7	59	X		
46	5:22:24	30 Aug 92	N2430522.24	-14	29	50	Side			59			
47	6:09:12	30 Aug 92	N2430609.12	-10	27	53	Side			59	X		
48	6:26:07	30 Aug 92	N2430626.07	-11	50	50	Side			59	X		
49	6:35:33	30 Aug 92	N2430635.33	-10	53	20	Bow		7	59	2X	Dn1	
50	6:52:43	30 Aug 92	N2430652.43	-11	49	2	Bow		7	59	X		

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
51	6:59:04	30 Aug 92	N2430659.04	-9	32	12	Bow		4	59	X		2
52	7:00:38	30 Aug 92	N2430700.38	-10	69	14	Bow		7	59	X		Excellent
53	7:04:10	30 Aug 92	N2430704.10	-12	80	7	Bow		6	59	X		
54	7:08:33	30 Aug 92	N2430708.33	-11	64	54	Side			59			Excellent
55	7:15:53	30 Aug 92	N2430715.53	-10	33	2	Bow		6	59	X		
56	7:16:38	30 Aug 92	N2430716.38	-10	53	8	Bow		6	59			
57	7:40:14	30 Aug 92	N2430740.14	-11	33	53	Side			59	X		
58	7:43:08	30 Aug 92	N2430743.08	-10	69	14	Bow		7	59	X		2
59	8:01:30	30 Aug 92	N2430801.30	-5	48	2	Bow		3	16	X	Dn1	
60	8:06:31	30 Aug 92	N2430806.31	-5	28	8	Bow		3	16		Dn1	
61	8:10:33	30 Aug 92	N2430810.33	-5	63	2	Bow		3	16	X	Dn1	
62	8:22:00	30 Aug 92	N2430822.00	-6	114	2	Bow		3	16	X	Dn1	
63	8:24:12	30 Aug 92	N2430824.12	-5	88	4	Bow		3	16	X	Dn2	
64	8:31:04	30 Aug 92	N2430831.04	-5	106	14	Bow		3	16		Dn1	
65	8:50:07	30 Aug 92	N2430850.07	-5	41	8	Bow		3	16	X	Dn1	
66	8:50:40	30 Aug 92	N2430850.40	-6	80	2	Bow		3	16	X	Dn1	
67	8:53:02	30 Aug 92	N2430853.02	-6	47	13	Bow		3	16	X	Dn1	
68	8:58:08	30 Aug 92	N2430858.08	-5	62	9	Bow		3	16	X	Dn1	
69	8:58:48	30 Aug 92	N2430858.48	-6	124	3	Bow		3	16	X	Dn1	
70	9:01:54	30 Aug 92	N2430901.54	-7	29	7	Bow		3	16	X	Dn1	
71	9:24:03	30 Aug 92	N2430924.03	-7	38	7	Bow		3	16	X	Dn1	Long
72	9:26:50	30 Aug 92	N2430926.50	-7	58	7	Bow		3	16	X	Dn1	
73	9:32:29	30 Aug 92	N2430932.29	-6	26	7	Bow		3	16	X	Dn1	2
74	9:37:34	30 Aug 92	N2430937.34	-5	42	8	Bow		3	16		Dn1	
75	9:42:17	30 Aug 92	N2430942.17	-5	41	2	Bow		3	16	X	Dn1	
76	9:57:16	30 Aug 92	N2430957.16	-5	36	3	Bow		3	16	X	Dn1	
77	10:27:37	30 Aug 92	N2431027.37	-7	56	7	Bow		3	16	X	Dn1	2
78	10:34:14	30 Aug 92	N2431034.14	-6	27	8	Bow		3	16	X	Dn1	
79	10:39:55	30 Aug 92	N2431039.55	-7	57	13	Bow		3	16	X	Dn1	
80	10:48:46	30 Aug 92	N2431048.46	-6	31	8	Bow		3	16	X	Dn1	
81	10:50:09	30 Aug 92	N2431050.09	-5	58	8	Bow		3	16	X	Dn1	Long
82	10:56:55	30 Aug 92	N2431056.55	-8	44	13	Bow		3	16	X	Dn1	
83	10:58:54	30 Aug 92	N2431058.54	-6	60	14	Bow		3	16	X	Dn1	
84	11:05:05	30 Aug 92	N2431105.05	-6	33	8	Bow		3	16	X	Dn1	2
85	12:55:32	30 Aug 92	N2431255.32	-8	27	7	Bow		3	16	X	Dn1	3
86	13:56:52	30 Aug 92	N2431356.52	-6	116	2	Bow		3	16	X		Very Long Impact
87	13:57:22	30 Aug 92	N2431357.22	-6	88	8	Bow		3	16	X		Same Imp
88	13:57:49	30 Aug 92	N2431357.49	-6	79	8	Bow		3	16	X		Same Imp
89	13:58:18	30 Aug 92	N2431358.18	-6	71	8	Bow		3	16	X		Same Imp
90	13:58:48	30 Aug 92	N2431358.48	-6	70	7	Bow		3	16	X		Same Imp
91	13:59:18	30 Aug 92	N2431359.18	-6	65	8	Bow		3	16	X		Same Imp
92	13:59:47	30 Aug 92	N2431359.47	-6	64	8	Bow		3	16	X		Same Imp
93	14:00:19	30 Aug 92	N2431400.19	-7	60	9	Bow		3	16	2X		Same Imp
94	14:00:52	30 Aug 92	N2431400.52	-6	62	8	Bow		3	16	X		Same Imp
95	14:01:18	30 Aug 92	N2431401.18	-6	60	8	Bow		3	16	X		Same Imp
96	14:01:46	30 Aug 92	N2431401.46	-6	59	8	Bow		3	16	X		Same Imp
97	14:02:14	30 Aug 92	N2431402.14	-6	64	8	Bow		3	16	X		Same Imp
98	14:05:31	30 Aug 92	N2431405.31	-6	41	7	Bow		3	16	X	Dn1	
99	14:10:05	30 Aug 92	N2431410.05	-6	77	2	Bow		3	16	X	Dn1	
100	14:10:38	30 Aug 92	N2431410.38	-5	34	12	Bow		3	16	X	Dn1	Many

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
101	14:12:15	30 Aug 92	N2431412.15	-9	57	13	Bow		3	16	X	Dn1	
102	14:13:52	30 Aug 92	N2431413.52	-15	233	5	Bow		3	16	X	Dn1	Excellent
103	14:31:25	30 Aug 92	N2431431.25	-7	73	8	Bow		3	16		Dn1	
104	14:32:00	30 Aug 92	N2431432.00	-6	42	2	Bow		3	16	X	Dn1	
105	14:48:16	30 Aug 92	N2431448.16	-12	227	6	Bow		3	16		Dn1	Excellent
106	14:50:13	30 Aug 92	N2431450.13	-6	38	8	Bow		3	16	X	Dn1	2
107	14:55:17	30 Aug 92	N2431455.17	-7	70	13	Bow		3	16	X	Dn1	
108	15:10:09	30 Aug 92	N2431510.09	-8	59	15	Bow		3	16	X	Dn1	
109	15:19:10	30 Aug 92	N2431519.10	-5	26	7	Bow		1	16	X	Dn1	
110	15:25:53	30 Aug 92	N2431525.53	-3	33	2	Bow		3	16	X	Dn1	3
111	15:35:16	30 Aug 92	N2431535.16	-6	49	7	Bow		3	16	X	Dn1	
112	16:15:49	30 Aug 92	N2431615.49	-5	88	7	Bow		3	16	X	Dn1	
113	16:24:07	30 Aug 92	N2431624.07	-5	30	7	Bow		3	16	X	Dn1	
114	16:29:58	30 Aug 92	N2431629.58	-4	45	2	Bow		3	16	X	Dn1	3
115	16:53:10	30 Aug 92	N2431653.10	-5	65	6	Bow		3	16		Dn1	2
116	16:53:53	30 Aug 92	N2431653.53	-5	33	8	Bow		3	16	X	Dn1	
117	16:57:14	30 Aug 92	N2431657.14	-4	50	8	Bow		3	16	X	Dn1	
118	16:57:45	30 Aug 92	N2431657.45	-4	30	7	Bow		3	16	X	Dn1	Long
119	17:25:47	30 Aug 92	N2431725.47	-5	31	7	Bow		3	16		Dn1	
120	17:28:50	30 Aug 92	N2431728.50	-6	43	8	Bow		3	16		Dn1	2
121	17:31:47	30 Aug 92	N2431731.47	-6	56	7	Bow		3	16	X	Dn1	
122	17:34:33	30 Aug 92	N2431734.33	-7	39	7	Bow		3	16	X	Dn1	
123	17:44:01	30 Aug 92	N2431744.01	-5	57	12	Bow		3	16	X	Dn1	
124	17:52:15	30 Aug 92	N2431752.15	-7	114	13	Bow		3	16	X	Dn1	3
125	17:53:16	30 Aug 92	N2431753.16	-5	91	14	Bow		3	16		Dn1	
126	17:53:52	30 Aug 92	N2431753.52	-7	55	7	Bow		3	16	X	Dn1	
127	17:54:24	30 Aug 92	N2431754.24	-4	26	8	Bow		3	16	X	Dn1	
128	17:56:05	30 Aug 92	N2431756.05	-5	49	11	Bow		3	16	X	Dn1	
129	17:58:53	30 Aug 92	N2431758.53	-5	40	15	Bow		3	16	X	Dn1	
130	18:09:34	30 Aug 92	N2431809.34	-5	25	7	Bow		3	16	X	Dn1	2
131	18:12:22	30 Aug 92	N2431812.22	-5	53	2	Bow		3	16	X	Dn1	2
132	18:13:12	30 Aug 92	N2431813.12	-5	26	7	Bow		3	16	X	Dn1	
133	18:15:05	30 Aug 92	N2431815.05	-5	30	9	Bow		3	16	2X	Dn2	
134	18:21:01	30 Aug 92	N2431821.01	-11	205	11	Bow		3	16		Dn1	Excellent
135	18:32:27	30 Aug 92	N2431832.27	-4	48	15	Bow		3	16	X	Dn1	
136	18:35:06	30 Aug 92	N2431835.06	-4	31	7	Bow		3	16	X	Dn1	2
137	18:35:52	30 Aug 92	N2431835.52	-6	44	6	Bow		3	16	X	Dn1	
138	18:38:50	30 Aug 92	N2431838.50	-4	49	7	Bow		3	16	X	Dn1	
139	18:44:32	30 Aug 92	N2431844.32	-7	42	7	Bow		3	16	X	Dn1	
140	18:56:34	30 Aug 92	N2431856.34	-6	59	6	Bow		3	16	X	Dn1	Long
141	19:02:29	30 Aug 92	N2431902.29	-8	58	13	Bow		3	16	X	Dn1	
142	19:06:52	30 Aug 92	N2431906.52	-12	243	5	Bow		3	16	X	Dn1	Excellent
143	19:07:40	30 Aug 92	N2431907.40	-6	31	8	Bow		2	16		Up1	
144	19:10:10	30 Aug 92	N2431910.10	-6	47	14	Bow		3	16	X	Dn1	3
145	19:13:34	30 Aug 92	N2431913.34	-13	72	7	Bow		3	16	X	Dn1	2
146	19:21:34	30 Aug 92	N2431921.34	-6	26	7	Bow		3	16	X	Dn1	5
147	19:37:41	30 Aug 92	N2431937.41	-7	40	7	Bow		3	16	X	Dn1	
148	19:48:18	30 Aug 92	N2431948.18	-6	32	8	Bow		3	16	X	Dn1	
149	19:49:49	30 Aug 92	N2431949.49	-9	137	6	Bow		3	16		Dn1	
150	19:57:00	30 Aug 92	N2431957.00	-7	97	6	Bow		3	16	X	Dn1	

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
151	19:58:41	30 Aug 92	N2431958.41	-7	47	7	Bow		3	16	X	Dn1	
152	20:18:11	30 Aug 92	N2432018.11	-6	33	7	Bow		3	16	X	Dn1	
153	20:49:22	30 Aug 92	N2432049.22	-5	37	8	Bow		3	16	X	Dn1	
154	21:05:36	30 Aug 92	N2432105.36	-6	26	7	Bow		3	16		Dn1	3
155	21:14:23	30 Aug 92	N2432114.23	-7	29	7	Bow		3	16		Dn1	2
156	21:17:16	30 Aug 92	N2432117.16	-10	73	13	Bow		3	16	X	Dn1	3
157	21:26:53	30 Aug 92	N2432126.53	-5	26	7	Bow		3	16	X	Dn1	Backing
158	21:33:52	30 Aug 92	N2432133.52	-5	29	7	Bow		3	16		Dn1	
159	21:36:31	30 Aug 92	N2432136.31	-12	159	5	Bow		3	16		Dn1	
160	21:38:35	30 Aug 92	N2432138.35	-8	57	6	Bow		3	16	X	Dn1	
161	22:40:10	30 Aug 92	N2432240.10	-10	96	11	Bow		3	16	X	Dn1	
162	22:40:45	30 Aug 92	N2432240.45	-4	33	7	Bow		3	16		Dn1	Long
163	23:33:27	30 Aug 92	N2432333.27	-6	51	13	Bow		3	16	X	Dn1	
164	23:37:02	30 Aug 92	N2432337.02	-4	67	15	Bow		3	16		Dn1	2
165	23:39:29	30 Aug 92	N2432339.29	-5	44	6	Bow		3	16		Dn1	
166	23:44:12	30 Aug 92	N2432344.12	-6	37	13	Bow		3	16	X	Dn1	
167	23:48:55	30 Aug 92	N2432348.55	-6	67	7	Bow		3	16		Dn1	
168	23:50:58	30 Aug 92	N2432350.58	-6	33	6	Bow		3	16	X	Dn1	
169	23:59:16	30 Aug 92	N2432359.16	-7	41	7	Bow		3	16	X	Dn1	
170	0:01:19	31 Aug 92	N2440001.19	-4	31	7	Bow		3	16		Dn1	
171	0:24:52	31 Aug 92	N2440024.52	-6	56	10	Bow		3	16	X	Dn1	
172	0:37:19	31 Aug 92	N2440037.19	-5	52	8	Bow		3	16		Dn1	
173	1:33:58	31 Aug 92	N2440133.58	-7	54	6	Bow		3	16		Dn1	
174	1:58:39	31 Aug 92	N2440158.39	-12	39	7	Bow		3	16	X	Dn1	
175	2:06:09	31 Aug 92	N2440206.09	-9	86	6	Bow		3	16		Dn1	
176	2:12:40	31 Aug 92	N2440212.40	-6	35	7	Bow		3	16	X	Dn1	
177	2:15:35	31 Aug 92	N2440215.35	-6	37	2	Bow		3	16		Dn1	3
178	2:32:40	31 Aug 92	N2440232.40	-6	49	7	Bow		3	16	X	Dn1	3
179	2:36:27	31 Aug 92	N2440236.27	-6	49	7	Bow		3	16	X	Dn1	2
180	2:38:54	31 Aug 92	N2440238.54	-8	85	7	Bow		3	16	X	Dn1	
181	2:43:51	31 Aug 92	N2440243.51	-5	53	8	Bow		3	16		Dn1	
182	2:44:24	31 Aug 92	N2440244.24	-5	59	8	Bow		3	16	X	Dn1	Long
183	3:15:21	31 Aug 92	N2440315.21	-8	71	5	Bow		3	16		Dn1	Long
184	3:23:55	31 Aug 92	N2440323.55	-7	113	13	Bow		3	16	X	Dn1	Long
185	3:33:19	31 Aug 92	N2440333.19	-8	41	5	Bow		3	16		Dn1	
186	3:41:00	31 Aug 92	N2440341.00	-10	152	6	Bow		3	16	X	Dn1	Long
187	4:02:24	31 Aug 92	N2440402.24	-8	65	7	Bow		3	16		Dn1	
188	4:23:48	31 Aug 92	N2440423.48	-9	105	5	Bow		2	16		Dn1	2
189	4:44:04	31 Aug 92	N2440444.04	-7	66	12	Bow		3	16		Dn1	
190	4:50:01	31 Aug 92	N2440450.01	-8	87	6	Bow		3	16		Dn1	
191	4:52:40	31 Aug 92	N2440452.40	-5	34	2	Bow		3	16		Dn1	
192	5:02:19	31 Aug 92	N2440502.19	-5	31	8	Bow		3	16		Dn1	
193	5:52:32	31 Aug 92	N2440552.32	-8	35	8	Bow		3	16	2X	Dn2	
194	6:02:30	31 Aug 92	N2440602.30	-6	54	7	Bow		3	16		Dn1	
195	6:19:46	31 Aug 92	N2440619.46	-6	77	5	Bow		3	16	X	Dn1	2
196	6:31:55	31 Aug 92	N2440631.55	-7	70	7	Bow		3	16		Dn1	
197	6:40:51	31 Aug 92	N2440640.51	-6	92	6	Bow		3	16		Dn1	
198	6:56:03	31 Aug 92	N2440656.03	-6	52	14	Bow		3	16		Dn1	2
199	7:02:41	31 Aug 92	N2440702.41	-6	34	7	Bow		3	16		Dn1	Long
200	7:12:42	31 Aug 92	N2440712.42	-8	72	6	Bow		3	16	X	Dn1	Long

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
201	7:15:35	31 Aug 92	N2440715.35	-6	67	13	Bow		3	16		Dn1	
202	7:18:40	31 Aug 92	N2440718.40	-6	56	8	Bow		3	16	X	Dn1	
203	7:20:27	31 Aug 92	N2440720.27	-5	48	6	Bow		3	16		Dn1	
204	7:22:33	31 Aug 92	N2440722.33	-8	96	7	Bow		3	16	X	Dn1	
205	7:37:14	31 Aug 92	N2440737.14	-4	35	8	Bow		1	16		Dn1	Spike
206	7:42:25	31 Aug 92	N2440742.25	-7	81	15	Bow		3	16	X	Dn1	
207	7:45:50	31 Aug 92	N2440745.50	-6	31	7	Bow		3	16		Dn1	Long
208	7:50:28	31 Aug 92	N2440750.28	-7	45	15	Bow		3	16	X	Dn1	
209	8:08:15	31 Aug 92	N2440808.15	-8	161	7	Bow		3	16		Dn1	
210	8:53:37	31 Aug 92	N2440853.37	-6	36	7	Bow		3	16	X	Dn1	3
211	8:56:02	31 Aug 92	N2440856.02	-7	77	6	Bow		3	16	X	Dn1	Long
212	9:13:50	31 Aug 92	N2440913.50	-8	94	6	Bow		3	16		Dn1	Spiky Event
213	9:15:28	31 Aug 92	N2440915.28	-6	51	5	Bow		3	16	2X	Dn2	
214	9:19:29	31 Aug 92	N2440919.29	-11	135	5	Bow		3	16		Dn1	2
215	9:22:33	31 Aug 92	N2440922.33	-6	34	7	Bow		3	16		Dn1	2
216	9:25:11	31 Aug 92	N2440925.11	-7	95	7	Bow		3	16		Dn1	
217	9:29:13	31 Aug 92	N2440929.13	-9	39	7	Bow		3	16		Dn1	
218	9:35:44	31 Aug 92	N2440935.44	-7	50	6	Bow		3	16		Dn1	
219	9:45:22	31 Aug 92	N2440945.22	-6	106	7	Bow		3	16		Dn1	
220	9:48:45	31 Aug 92	N2440948.45	-7	37	7	Bow		2	16		Dn1	
221	9:51:13	31 Aug 92	N2440951.13	-6	34	16	Bow		3	16		Dn1	
222	10:02:27	31 Aug 92	N2441002.27	-7	32	7	Bow		3	16		Dn1	
223	10:18:30	31 Aug 92	N2441018.30	-7	54	7	Bow		3	16	2X	Dn2	2
224	10:23:36	31 Aug 92	N2441023.36	-12	75	3	Bow		3	16		Dn1	
225	10:31:31	31 Aug 92	N2441031.31	-8	92	14	Bow		3	16	X	Dn1	3
226	13:25:12	31 Aug 92	N2441325.12	-6	73	7	Bow		3	16	X	Dn1	Long
227	13:31:30	31 Aug 92	N2441331.30	-4	34	7	Bow		3	16		Dn1	2
228	13:46:55	31 Aug 92	N2441346.55	-14	199	5	Bow		3	16		Dn1	Excellent
229	13:54:54	31 Aug 92	N2441354.54	-7	77	13	Bow		3	16	X	Dn1	
230	13:58:03	31 Aug 92	N2441358.03	-5	41	16	Bow		3	16	X	Dn1	2
231	14:04:40	31 Aug 92	N2441404.40	-5	30	16	Bow		1	16	X	Dn1	Spiky Event
232	14:27:56	31 Aug 92	N2441427.56	-5	58	4	Bow		3	16	X	Dn1	2
233	16:53:09	31 Aug 92	N2441653.09	-8	119	5	Bow		3	16		Dn1	2
234	16:56:46	31 Aug 92	N2441656.46	-5	49	12	Bow		3	16		Dn1	
235	17:00:45	31 Aug 92	N2441700.45	-12	97	13	Bow		3	16	X	Dn1	
236	17:13:53	31 Aug 92	N2441713.53	-4	36	15	Bow		3	16	X	Dn1	2
237	17:20:29	31 Aug 92	N2441720.29	-3	41	16	Bow		3	16	X	Dn1	
238	17:23:48	31 Aug 92	N2441723.48	-3	63	9	Bow		3	16		Dn1	
239	17:35:54	31 Aug 92	N2441735.54	-6	43	9	Bow		3	16	X	Dn1	
240	17:46:13	31 Aug 92	N2441746.13	-5	57	1	Bow		3	16	X	Dn1	2
241	17:50:35	31 Aug 92	N2441750.35	-5	52	13	Bow		3	16	X	Dn1	
242	20:29:55	31 Aug 92	N2442029.55	-14	49	1	Bow		2	59	X		Long - Next
243	20:30:22	31 Aug 92	N2442030.22	-14	97	52	Side	Bow	7	59	X	Dn1	Excellent
244	20:37:36	31 Aug 92	N2442037.36	-15	181	49	Side			59			Excellent
245	20:43:03	31 Aug 92	N2442043.03	-12	31	55	Transom			59			Excellent
246	20:45:39	31 Aug 92	N2442045.39	-13	36	32	Bow		6	59			2
247	20:51:48	31 Aug 92	N2442051.48	-13	35	49	Side			59			Excellent
248	20:53:29	31 Aug 92	N2442053.29	-14	83	9	Bow		7	59			2
249	20:55:00	31 Aug 92	N2442055.00	-14	16	51	Side			59			Long
250	20:56:29	31 Aug 92	N2442056.29	-14	18	49	Side			59			2

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
251	20:59:09	31 Aug 92	N2442059.09	-20	36	20	Bow	Side	7	59			2
252	21:00:10	31 Aug 92	N2442100.10	-10	42	49	Side	Bow	3	59	2X		Long
253	21:07:06	31 Aug 92	N2442107.06	-13	15	55	Transom			59			
254	21:08:45	31 Aug 92	N2442108.45	-13	43	16	Bow	Side	7	59			2
255	21:10:28	31 Aug 92	N2442110.28	-14	42	16	Bow	Side	7	59			
256	21:11:32	31 Aug 92	N2442111.32	-12	38	39	Bow		7	59			
257	21:12:15	31 Aug 92	N2442112.15	-12	57	28	Bow	Side	6	59	X		
258	21:15:16	31 Aug 92	N2442115.16	-15	36	1	Bow		7	59			
259	21:18:24	31 Aug 92	N2442118.24	-13	175	53	Side	Bow	4	59			2
260	21:19:10	31 Aug 92	N2442119.10	-13	50	8	Bow		4	59			Long
261	21:22:08	31 Aug 92	N2442122.08	-12	34	30	Bow		7	59	X		
262	21:23:23	31 Aug 92	N2442123.23	-11	22	25	Bow	Side	5	59	2X	Dn1	
263	21:26:30	31 Aug 92	N2442126.30	-12	20	51	Side			59			
264	21:27:48	31 Aug 92	N2442127.48	-13	17	50	Side	Bow	6	59			
265	21:29:09	31 Aug 92	N2442129.09	-12	27	50	Side			59			Backing
266	21:29:56	31 Aug 92	N2442129.56	-14	32	33	Bow	Side	7	59	X		
267	21:30:55	31 Aug 92	N2442130.55	-13	14	57	Transom			59			
268	21:31:38	31 Aug 92	N2442131.38	-15	20	58	Side			59			Trig. by Trans Spike
269	21:32:14	31 Aug 92	N2442132.14	-13	75	16	Bow		6	59	X		
270	21:37:13	31 Aug 92	N2442137.13	-12	11	57	Transom			59			
271	21:42:08	31 Aug 92	N2442142.08	-10	15	58	Transom			59			
272	21:44:13	31 Aug 92	N2442144.13	-10	76	57	Transom			59			
273	21:46:29	31 Aug 92	N2442146.29	-10	52	58	Transom			59			
274	21:49:51	31 Aug 92	N2442149.51	-10	8	55	Transom			59			No Good
275	21:53:31	31 Aug 92	N2442153.31	-10	9	57	Transom			59			Tiny in Noise
276	21:56:16	31 Aug 92	N2442156.16	-10	89	56	Transom			59			4 Spikes
277	21:57:08	31 Aug 92	N2442157.08	-10	93	58	Transom			59			Excellent
278	21:58:09	31 Aug 92	N2442158.09	-10	75	10	Bow		5	59	X		
279	22:02:04	31 Aug 92	N2442202.04	-18	47	16	Bow		7	59			Long
280	22:03:56	31 Aug 92	N2442203.56	-39	8	57	Transom			59			No Data
281	22:04:33	31 Aug 92	N2442204.33	-14	15	58	Transom			59			Milling
282	22:05:25	31 Aug 92	N2442205.25	-13	100	36	Bow		6	59		Dn1	
283	22:07:49	31 Aug 92	N2442207.49	-12	19	55	Transom			59	X		Long
284	22:10:22	31 Aug 92	N2442210.22	-23	45	56	Transom			59			Spike
285	22:14:13	31 Aug 92	N2442214.13	-12	17	57	Transom			59			Long
286	22:29:34	31 Aug 92	N2442229.34	-12	106	3	Bow		6	59	X	Dn1	2
287	22:32:55	31 Aug 92	N2442232.55	-12	70	49	Side			59			
288	22:36:45	31 Aug 92	N2442236.45	-11	96	32	Bow		6	59			
289	22:38:44	31 Aug 92	N2442238.44	-11	8	55	Transom			59			Neg. Spike
290	22:39:58	31 Aug 92	N2442239.58	-11	9	55	Transom			59			Tiny in Noise
291	22:40:56	31 Aug 92	N2442240.56	-11	11	58	Transom			59			Spike
292	22:41:45	31 Aug 92	N2442241.45	-11	17	29	Bow	Side	5	59	3X	Dn3	2
293	23:17:15	31 Aug 92	N2442317.15	-30	10	55	Transom			59			Neg Spike
294	23:18:01	31 Aug 92	N2442318.01	-11	10	55	Transom			59			Drift
295	23:18:31	31 Aug 92	N2442318.31	-13	102	31	Bow		7	59		Dn1	
296	23:19:00	31 Aug 92	N2442319.00	-11	59	40	Bow		7	59		Dn1	
297	23:27:20	31 Aug 92	N2442327.20	-10	19	49	Side			59			
298	23:28:33	31 Aug 92	N2442328.33	-15	11	43	Transom			59			Btm Drift
299	23:29:44	31 Aug 92	N2442329.44	-11	37	43	Bottom	Bow	3	59			Good
300	23:30:14	31 Aug 92	N2442330.14	-12	30	34	Bow		2	59		Dn1	

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
301	23:31:06	31 Aug 92	N2442331.06	-11	14	44	Bottom			59			Good, Backing
302	23:32:39	31 Aug 92	N2442332.39	-10	27	40	Bow	Side	3	59	2X	Dn1	
303	23:35:04	31 Aug 92	N2442335.04	-11	12	50	Side	Bow	2	59			Small
304	23:44:56	31 Aug 92	N2442344.56	-10	21	58	Transom			59			Spike
305	23:50:19	31 Aug 92	N2442350.19	-12	21	59	Transom			59			2
306	23:51:07	31 Aug 92	N2442351.07	-11	41	16	Bow		7	59			
307	23:53:16	31 Aug 92	N2442353.16	-10	137	29	Bow		7	59	X		2, Long
308	23:58:36	31 Aug 92	N2442358.36	-16	275	17	Bow		7	59	X		2, Excellent
309	0:01:03	1 Sep 92	N2450001.03	-9	137	14	Bow		7	59			Excellent
310	0:03:16	1 Sep 92	N2450003.16	-9	89	51	Side	Bow	1	59			
311	0:04:02	1 Sep 92	N2450004.02	-10	11	50	Side	Bow	7	59			
312	0:08:36	1 Sep 92	N2450008.36	-9	46	8	Bow		4	59	2X		2
313	0:09:51	1 Sep 92	N2450009.51	-9	21	52	Side			59			Backing
314	0:11:41	1 Sep 92	N2450011.41	-9	20	58	Transom			59			
315	0:13:53	1 Sep 92	N2450013.53	-10	37	50	Side			59			Long
316	0:16:03	1 Sep 92	N2450016.03	-10	96	41	Bow		7	59			Cusp Failure
317	0:16:58	1 Sep 92	N2450016.58	-10	188	51	Side			59			Excellent
318	0:19:01	1 Sep 92	N2450019.01	-10	39	5	Bow		7	59	X		4
319	0:20:14	1 Sep 92	N2450020.14	-9	38	50	Side			59			
320	0:21:56	1 Sep 92	N2450021.56	-9	91	30	Bow		7	59	X		2
321	0:31:02	1 Sep 92	N2450031.02	-8	124	22	Bow		5	59			
322	0:34:10	1 Sep 92	N2450034.10	-6	36	50	Side	Bow	7	59	3X		
323	1:01:42	1 Sep 92	N2450101.42	-7	122	54	Side	Bow	7	59	X	Dn1	3, Good
324	1:04:53	1 Sep 92	N2450104.53	-8	23	50	Side			59			2
325	1:05:27	1 Sep 92	N2450105.27	-8	26	53	Side	Bow	6	59	10X		
326	1:06:16	1 Sep 92	N2450106.16	-8	85	50	Side			59			Backing
327	1:07:30	1 Sep 92	N2450107.30	-8	24	54	Side			59			
328	1:08:55	1 Sep 92	N2450108.55	-9	60	15	Bow		4	59	X		Long, Backing
329	1:10:57	1 Sep 92	N2450110.57	-8	33	51	Side			59			2
330	1:11:28	1 Sep 92	N2450111.28	-8	88	53	Side	Bow	7	59	X	Dn1	
331	1:15:30	1 Sep 92	N2450115.30	-22	85	58	Transom			59			2, Excellent
332	1:16:50	1 Sep 92	N2450116.50	-9	86	24	Bow		7	59	2X	Dn1	Cusp Failure
333	1:21:58	1 Sep 92	N2450121.58	-8	31	50	Side	Bow	7	59			3
334	1:25:31	1 Sep 92	N2450125.31	-12	42	21	Bow		4	59	X		
335	1:31:16	1 Sep 92	N2450131.16	-9	41	16	Bow		5	59	X		
336	1:32:32	1 Sep 92	N2450132.32	-9	18	51	Side			59			Long
337	1:37:03	1 Sep 92	N2450137.03	-16	45	56	Transom			59			3, Excellent
338	1:38:24	1 Sep 92	N2450138.24	-10	117	18	Bow		7	59	X		2, Long
339	1:39:37	1 Sep 92	N2450139.37	-10	58	11	Bow		4	59	X		
340	1:41:36	1 Sep 92	N2450141.36	-10	58	31	Bow		7	59	X		3
341	1:45:21	1 Sep 92	N2450145.21	-11	81	52	Side			59			Long
342	10:39:23	1 Sep 92	N2451039.23	-27	86	42	Bow		7	59			
343	10:42:04	1 Sep 92	N2451042.04	-25	95	41	Bow		7	59	X		Long, Excellent
344	10:45:03	1 Sep 92	N2451045.03	-23	181	36	Bow		5	59			Excellent
345	10:51:26	1 Sep 92	N2451051.26	-26	11	58	Transom			59			
346	10:56:30	1 Sep 92	N2451056.30	-27	31	55	Transom			59			
347	10:57:45	1 Sep 92	N2451057.45	-27	41	49	Side	Bow	2	59			
348	11:17:27	1 Sep 92	N2451117.27	-14	48	16	Bow		5	59	X		
349	11:30:15	1 Sep 92	N2451130.15	-56	24	51	Side	Bow	5	59			
350	11:34:12	1 Sep 92	N2451134.12	-11	56	54	Side			59			

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
351	11:44:01	1 Sep 92	N2451144.01	-25	24	56	Side			59			Trig. by Trans. Spike
352	11:49:17	1 Sep 92	N2451149.17	-31	69	56	Transom			59			Spike
353	11:55:28	1 Sep 92	N2451155.28	-12	45	58	Transom			59			Excellent
354	12:00:24	1 Sep 92	N2451200.24	-12	23	49	Side			59			3
355	12:06:42	1 Sep 92	N2451206.42	-12	26	58	Transom			59			Excellent
356	12:13:00	1 Sep 92	N2451213.00	-13	33	57	Transom			59			Excellent
357	14:54:52	1 Sep 92	N2451454.52	-9	176	49	Side			59			Excellent
358	14:55:26	1 Sep 92	N2451455.26	-9	13	58	Transom			59			Long, Milling, Fwd
359	14:56:05	1 Sep 92	N2451456.05	-9	127	49	Side			59			Excellent
360	14:58:49	1 Sep 92	N2451458.49	-12	102	34	Bow		7	59			2
361	15:08:25	1 Sep 92	N2451508.25	-8	89	50	Side			59			
362	15:15:18	1 Sep 92	N2451515.18	-8	14	58	Transom			59	2X		
363	15:17:14	1 Sep 92	N2451517.14	-8	19	58	Transom			59			Spike
364	15:21:55	1 Sep 92	N2451521.55	-9	59	16	Bow		7	59			2
365	15:26:48	1 Sep 92	N2451526.48	-10	136	4	Bow		7	59			
366	15:35:45	1 Sep 92	N2451535.45	-12	29	58	Bow		1	59	X		Trig. by Trans. Spike
367	15:39:22	1 Sep 92	N2451539.22	-8	61	29	Bow		7	59	X		4
368	16:11:21	1 Sep 92	N2451611.21	-8	20	49	Side			59			2, Noisy
369	16:11:52	1 Sep 92	N2451611.52	-10	116	52	Side	Bow	7	59		Dn1	Excellent
370	16:15:05	1 Sep 92	N2451615.05	-8	47	50	Side	Bow	4	59			Long
371	16:16:48	1 Sep 92	N2451616.48	-8	175	49	Side			59			2
372	16:22:36	1 Sep 92	N2451622.36	-7	53	53	Side			59	2X		
373	16:23:14	1 Sep 92	N2451623.14	-23	19	57	Transom	Side		59			Noise on both Panels
374	16:26:14	1 Sep 92	N2451626.14	-10	60	51	Side			59			
375	16:29:11	1 Sep 92	N2451629.11	-7	25	58	Transom			59			Excellent
376	16:30:12	1 Sep 92	N2451630.12	-8	37	13	Bow	Bottom	7	59			2
377	16:32:26	1 Sep 92	N2451632.26	-8	21	54	Side	Transom		59			
378	16:33:57	1 Sep 92	N2451633.57	-8	14	49	Side	Bow	7	59			
379	16:34:50	1 Sep 92	N2451634.50	-10	39	36	Bow		7	59	X		Long
380	16:37:11	1 Sep 92	N2451637.11	-8	55	49	Side	Bow	7	59			
381	16:39:23	1 Sep 92	N2451639.23	-9	54	35	Bow	Side	7	59			2
382	16:44:14	1 Sep 92	N2451644.14	-9	32	49	Side			59	3X		3
383	16:53:55	1 Sep 92	N2451653.55	-13	210	49	Side	Bow	7	59			2, Excellent
384	16:56:45	1 Sep 92	N2451656.45	-9	153	49	Side			59			Excellent
385	16:57:21	1 Sep 92	N2451657.21	-9	20	12	Bow	Bottom	6	59	X		
386	17:02:34	1 Sep 92	N2451702.34	-8	22	53	Side			59			
387	17:05:19	1 Sep 92	N2451705.19	-10	64	10	Bow		7	59	X		2
388	17:07:40	1 Sep 92	N2451707.40	-9	187	50	Side			59			Excellent, Backing
389	17:11:29	1 Sep 92	N2451711.29	-10	85	8	Bow		7	59			
390	17:13:42	1 Sep 92	N2451713.42	-14	20	51	Side			59			
391	17:14:46	1 Sep 92	N2451714.46	-14	252	49	Side	Bow	2	59	X		Excellent
392	17:16:26	1 Sep 92	N2451716.26	-9	43	49	Side	Bow	5	59			
393	17:25:20	1 Sep 92	N2451725.20	-13	126	11	Bow		7	59	X		
394	17:27:44	1 Sep 92	N2451727.44	-8	93	17	Bow	Bottom	7	59	X		2
395	17:29:41	1 Sep 92	N2451729.41	-8	46	49	Side			59			
396	17:30:34	1 Sep 92	N2451730.34	-9	58	49	Side			59			
397	17:32:08	1 Sep 92	N2451732.08	-8	23	58	Transom			59			Spiky Event
398	17:33:17	1 Sep 92	N2451733.17	-9	71	15	Bow		5	59	X		
399	17:35:52	1 Sep 92	N2451735.52	-7	48	49	Side			59			
400	17:36:38	1 Sep 92	N2451736.38	-8	11	58	Transom	Bow	2	59			Noisy

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
401	17:38:16	1 Sep 92	N2451738.16	-10	71	16	Bow		7	59			
402	17:41:27	1 Sep 92	N2451741.27	-10	20	50	Side	Bow	6	59	X		Long
403	17:44:16	1 Sep 92	N2451744.16	-12	13	50	Side			59			
404	17:45:13	1 Sep 92	N2451745.13	-8	119	52	Side			59			Excellent, Backing
405	17:46:54	1 Sep 92	N2451746.54	-8	134	21	Bow		7	59			2, Backing
406	17:48:47	1 Sep 92	N2451748.47	-8	111	50	Side			59			Excellent
407	17:50:13	1 Sep 92	N2451750.13	-22	65	7	Bow	Transom	3	59	X		2
408	17:51:39	1 Sep 92	N2451751.39	-10	75	53	Side			59			Long, Backing
409	17:53:18	1 Sep 92	N2451753.18	-10	30	34	Bow	Side	6	59	X		2
410	17:54:51	1 Sep 92	N2451754.51	-9	125	52	Side			59			Excellent
411	17:59:36	1 Sep 92	N2451759.36	-9	50	10	Bow		3	59	X		
412	18:03:57	1 Sep 92	N2451803.57	-8	11	38	Bow			59			Drift
413	18:05:36	1 Sep 92	N2451805.36	-7	77	49	Side	Bow	4	59			
414	18:08:08	1 Sep 92	N2451808.08	-8	131	53	Side			59			Excellent
415	18:12:31	1 Sep 92	N2451812.31	-8	53	1	Bow		5	59	X		2
416	18:14:53	1 Sep 92	N2451814.53	-7	16	4	Bow	Side	5	59			2
417	18:17:25	1 Sep 92	N2451817.25	-8	79	34	Bow		7	59	15X		
418	18:18:25	1 Sep 92	N2451818.25	-8	84	56	Bow		5	59			Trig. by Trans. Spike
419	18:18:57	1 Sep 92	N2451818.57	-8	32	53	Side	Bow	6	59	X	Dn1	
420	18:20:10	1 Sep 92	N2451820.10	-12	135	4	Bow		7	59	X		Excellent
421	18:22:40	1 Sep 92	N2451822.40	-8	84	56	Side			59			2,Trig by Trans Spike
422	18:23:29	1 Sep 92	N2451823.29	-9	40	25	Bow	Side	7	59	X		2
423	18:26:39	1 Sep 92	N2451826.39	-8	45	20	Bow	Side	7	59			3
424	18:27:54	1 Sep 92	N2451827.54	-11	48	59	Transom	Side		59			Spiky Event
425	18:29:53	1 Sep 92	N2451829.53	-10	14	58	Transom			59			Spiky Event
426	18:34:41	1 Sep 92	N2451834.41	-9	32	16	Bow		4	59	X		
427	18:36:55	1 Sep 92	N2451836.55	-10	15	58	Transom			59			
428	18:39:18	1 Sep 92	N2451839.18	-10	62	4	Bow		7	59	X		2
429	18:40:27	1 Sep 92	N2451840.27	-9	61	49	Side			59			3
430	18:44:25	1 Sep 92	N2451844.25	-9	126	56	Bow	Side	7	59	X		2,Trig by Trans Spike
431	18:45:33	1 Sep 92	N2451845.33	-9	54	28	Bow		7	59	X		
432	18:47:30	1 Sep 92	N2451847.30	-12	78	51	Side	Bow	1	59	3X		Backing
433	18:49:05	1 Sep 92	N2451849.05	-23	52	23	Bow		7	59	X		3
434	18:51:40	1 Sep 92	N2451851.40	-10	85	22	Bow		6	59	X		
435	18:55:40	1 Sep 92	N2451855.40	-10	23	40	Bow		3	59	X		2, Long
436	18:56:13	1 Sep 92	N2451856.13	-13	184	51	Side			59			Excellent
437	18:58:36	1 Sep 92	N2451858.36	-9	47	50	Side			59			2
438	19:00:02	1 Sep 92	N2451900.02	-10	95	54	Side	Bow	3	59	X		
439	19:00:55	1 Sep 92	N2451900.55	-11	62	16	Bow		7	59	X		
440	19:01:39	1 Sep 92	N2451901.39	-10	104	28	Bow		3	59	X		Long
441	19:04:32	1 Sep 92	N2451904.32	-9	43	56	Bow	Side	2	59			Trig. by Trans. Spike
442	19:05:08	1 Sep 92	N2451905.08	-10	32	50	Side	Bow	6	59	2X		
443	19:07:35	1 Sep 92	N2451907.35	-9	14	44	Bottom	Transom		59			Excellent
444	19:08:59	1 Sep 92	N2451908.59	-10	24	50	Side	Bow	6	59			
445	19:10:36	1 Sep 92	N2451910.36	-10	22	35	Bow	Side	2	59	X		Backing
446	19:11:05	1 Sep 92	N2451911.05	-9	51	52	Side	Transom		59			Backing
447	19:11:38	1 Sep 92	N2451911.38	-9	34	49	Side			59			
448	19:12:15	1 Sep 92	N2451912.15	-10	44	12	Bow	Side	7	59	X	Dn1	
449	19:14:32	1 Sep 92	N2451914.32	-11	51	50	Side			59			
450	19:15:06	1 Sep 92	N2451915.06	-11	22	17	Bow	Side	7	59		Dn1	2

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
451	19:19:50	1 Sep 92	N2451919.50	-10	69	50	Side	Transom		59			
452	19:34:35	1 Sep 92	N2451934.35	-10	64	50	Side			59			
453	19:36:14	1 Sep 92	N2451936.14	-84	18	58	Transom			59	2X		
454	19:45:17	1 Sep 92	N2451945.17	-10	58	49	Side	Bow	6	59	X		3
455	19:47:54	1 Sep 92	N2451947.54	-9	48	16	Bow		3	59			Spiky Event
456	19:55:26	1 Sep 92	N2451955.26	-15	21	58	Transom			59			Excellent
457	19:56:11	1 Sep 92	N2451956.11	-11	52	16	Bow		7	59			
458	19:58:33	1 Sep 92	N2451958.33	-10	79	56	Bow	Btm, Side	6	59	X		Trig. by Trans. Spike
459	20:00:44	1 Sep 92	N2452000.44	-11	103	23	Bow		7	59	X		2
460	20:17:04	1 Sep 92	N2452017.04	-9	18	58	Transom			59			Simult. All Chans
461	20:22:50	1 Sep 92	N2452022.50	-9	108	17	Bow		7	59	X		
462	20:26:05	1 Sep 92	N2452026.05	-12	63	42	Bow		7	59		Dn1	2
463	20:26:58	1 Sep 92	N2452026.58	-12	89	8	Bow		7	59			
464	20:28:20	1 Sep 92	N2452028.20	-11	132	6	Bow		7	59	X		
465	20:33:29	1 Sep 92	N2452033.29	-10	41	54	Side			59			Slow Backing
466	20:35:17	1 Sep 92	N2452035.17	-9	52	16	Bow		7	59	X		
467	20:40:27	1 Sep 92	N2452040.27	-10	33	15	Bow		7	59			2
468	20:43:12	1 Sep 92	N2452043.12	-9	21	59	Transom			59			Milling
469	20:49:00	1 Sep 92	N2452049.00	-15	23	50	Side			59			
470	20:51:05	1 Sep 92	N2452051.05	-11	67	53	Side	Bow	4	59			
471	20:51:34	1 Sep 92	N2452051.34	-13	54	51	Side	Bow	6	59			2 Long
472	20:53:03	1 Sep 92	N2452053.03	-10	57	50	Side			59	3X		Long, Backing
473	21:14:25	1 Sep 92	N2452114.25	-12	14	28	Bow	Bottom	7	59	X		2
474	21:15:34	1 Sep 92	N2452115.34	-10	58	10	Bow		7	59			
475	21:16:02	1 Sep 92	N2452116.02	-11	6	46	Bottom			59			Drift
476	21:17:10	1 Sep 92	N2452117.10	-10	7	46	Bottom			59			Drift
477	21:17:41	1 Sep 92	N2452117.41	-10	7	46	Bottom			59			Drift
478	21:18:09	1 Sep 92	N2452118.09	-11	7	46	Bottom			59			Drift
479	21:18:55	1 Sep 92	N2452118.55	-12	7	46	Bottom			59			Drift
480	21:19:26	1 Sep 92	N2452119.26	-11	7	46	Bottom			59			Drift
481	21:19:56	1 Sep 92	N2452119.56	-11	7	46	Bottom			59			Drift
482	21:20:27	1 Sep 92	N2452120.27	-10	72	2	Bow		7	59	X		2
483	21:21:00	1 Sep 92	N2452121.00	-10	7	46	Bottom			59			Drift
484	21:21:26	1 Sep 92	N2452121.26	-13	78	13	Bow		6	59	X	Dn1	
485	21:21:54	1 Sep 92	N2452121.54	-11	30	12	Bow		4	59	X	Dn1	
486	21:22:23	1 Sep 92	N2452122.23	-11	7	46	Bottom			59			Drift
487	21:22:52	1 Sep 92	N2452122.52	-10	7	46	Bottom			59			Drift
488	21:23:20	1 Sep 92	N2452123.20	-11	60	56	Transom			59			Spike
489	21:24:11	1 Sep 92	N2452124.11	-11	90	56	Transom			59			Spike
490	21:24:41	1 Sep 92	N2452124.41	-10	7	46	Bottom			59			Drift
491	21:25:13	1 Sep 92	N2452125.13	-9	7	46	Side			59			Non-event
492	21:25:52	1 Sep 92	N2452125.52	-10	15	24	Bow		4	59	3X	Dn2	2
493	23:15:03	1 Sep 92	N2452315.03	-9	45	1	Bow		7	59	X		2
494	23:24:33	1 Sep 92	N2452324.33	-11	24	44	Bottom	Bow	6	59	X		2, Excellent
495	23:34:55	1 Sep 92	N2452334.55	-20	55	4	Bow		7	59	X		
496	23:36:27	1 Sep 92	N2452336.27	-34	51	3	Bow		7	59	X		
497	0:00:35	2 Sep 92	N2460000.35	-10	125	10	Bow		7	59	X		2
498	0:03:35	2 Sep 92	N2460003.35	-10	40	51	Side	Bow	3	59	X		2
499	0:35:14	2 Sep 92	N2460035.14	-15	36	51	Side			59			Backing
500	0:36:30	2 Sep 92	N2460036.30	-15	58	50	Side	Bow	6	59			

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
501	0:38:55	2 Sep 92	N2460038.55	-16	46	27	Bow	Side, Btm	5	59	X		
502	0:44:21	2 Sep 92	N2460044.21	-19	32	51	Side	Bow	7	59	2X	Dn1	
503	0:49:53	2 Sep 92	N2460049.53	-21	303	51	Side			59			Excellent
504	0:53:59	2 Sep 92	N2460053.59	-21	36	10	Bow		5	59	X		Long
505	1:00:37	2 Sep 92	N2460100.37	-22	41	51	Side	Bow	6	59	X		2
506	1:09:40	2 Sep 92	N2460109.40	-21	30	58	Transom			59			Excellent, Milling
507	1:13:14	2 Sep 92	N2460113.14	-21	54	56	Transom			59			Spike
508	1:23:48	2 Sep 92	N2460123.48	-19	103	7	Bow		7	59	X	Dn1	
509	1:30:15	2 Sep 92	N2460130.15	-20	38	58	Transom			59			Excellent
510	1:35:47	2 Sep 92	N2460135.47	-21	60	54	Side			59			
511	1:40:14	2 Sep 92	N2460140.14	-19	12	58	Transom			59			Noisy
512	1:45:58	2 Sep 92	N2460145.58	-18	27	58	Transom			59			
513	1:48:13	2 Sep 92	N2460148.13	-18	59	16	Bow		5	59	X		Long
514	1:54:22	2 Sep 92	N2460154.22	-19	65	56	Transom			59			Spike
515	1:56:57	2 Sep 92	N2460156.57	-19	31	29	Bow	Side	6	59	X		
516	2:00:32	2 Sep 92	N2460200.32	-17	34	59	Transom			59			Excellent
517	4:51:36	2 Sep 92	N2460451.36	-35	30	59	Transom			59			Milling, Neg. Spike
518	4:52:15	2 Sep 92	N2460452.15	-23	32	49	Side			59			
519	4:54:26	2 Sep 92	N2460454.26	-21	74	13	Bow		7	59			
520	4:55:08	2 Sep 92	N2460455.08	-21	27	50	Side	Bow	2	59	X		Long
521	4:56:28	2 Sep 92	N2460456.28	-103	157	50	Side	Transom		59			Noise, Neg. Spike
522	4:56:59	2 Sep 92	N2460456.59	-7	27	30	Bow	Side	6	59	X	Dn2	
523	4:57:39	2 Sep 92	N2460457.39	-12	41	52	Side	Bow	5	59	X		
524	5:00:33	2 Sep 92	N2460500.33	-12	146	30	Bow		7	59			Excellent
525	5:02:31	2 Sep 92	N2460502.31	-84	36	56	Transom			59			Neg. Spike
526	5:03:28	2 Sep 92	N2460503.28	-8	83	27	Bow		7	59	X		
527	5:07:05	2 Sep 92	N2460507.05	-8	16	50	Side	Bow	5	59	X		
528	5:09:22	2 Sep 92	N2460509.22	-6	42	50	Side	Bow	7	59	X		2
529	5:20:29	2 Sep 92	N2460520.29	-7	12	57	Transom			59			
530	5:23:56	2 Sep 92	N2460523.56	-9	26	50	Side	Bow	1	59	X		Long
531	5:26:12	2 Sep 92	N2460526.12	-8	102	16	Bow		6	59	X		
532	5:28:28	2 Sep 92	N2460528.28	-5	39	18	Bow		5	59	X		Long
533	5:40:59	2 Sep 92	N2460540.59	-11	45	15	Bow		4	59	X		
534	5:44:37	2 Sep 92	N2460544.37	-7	37	31	Bow	Side	7	59	X		
535	5:45:12	2 Sep 92	N2460545.12	-7	20	50	Side			59			
536	5:49:52	2 Sep 92	N2460549.52	-8	71	11	Bow		7	59			
537	5:51:03	2 Sep 92	N2460551.03	-7	38	49	Side			59			
538	5:55:14	2 Sep 92	N2460555.14	-8	43	33	Bow		7	59	X		
539	5:56:10	2 Sep 92	N2460556.10	-29	74	26	Bow		5	59	X		2
540	5:56:41	2 Sep 92	N2460556.41	-7	43	7	Bow	Side	4	59	X		
541	5:57:13	2 Sep 92	N2460557.13	-8	28	50	Side			59			
542	5:59:10	2 Sep 92	N2460559.10	-7	47	6	Bow		7	59	X	Dn1	
543	6:00:35	2 Sep 92	N2460600.35	-7	56	35	Bow		7	59			
544	6:01:55	2 Sep 92	N2460601.55	-8	66	4	Bow		7	59			
545	6:02:38	2 Sep 92	N2460602.38	-8	47	5	Bow		7	59	X		3
546	6:03:16	2 Sep 92	N2460603.16	-57	17	50	Side	Bow	2	59	X		
547	6:14:07	2 Sep 92	N2460614.07	-26	32	51	Side			59			
548	6:18:45	2 Sep 92	N2460618.45	-9	12	51	Side			59			
549	6:19:29	2 Sep 92	N2460619.29	-9	56	54	Side			59			
550	6:23:57	2 Sep 92	N2460623.57	-12	44	57	Transom			59			3, Excellent, Milling

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
551	6:24:40	2 Sep 92	N2460624.40	-10	25	50	Side			59			
552	6:25:16	2 Sep 92	N2460625.16	-10	38	2	Bow		2	59	2X		Long Evt on 1 Gage
553	6:26:00	2 Sep 92	N2460626.00	-10	12	50	Side			59			Backing
554	6:27:18	2 Sep 92	N2460627.18	-14	24	53	Side			59			
555	6:28:01	2 Sep 92	N2460628.01	-10	26	36	Bow	Side	7	59	X		2
556	6:31:58	2 Sep 92	N2460631.58	-10	16	50	Side			59			2
557	6:34:15	2 Sep 92	N2460634.15	-18	120	56	Transom	Side		59			Excel., Backing, Mill.
558	6:36:20	2 Sep 92	N2460636.20	-12	48	57	Transom			59			Excellent
559	6:37:10	2 Sep 92	N2460637.10	-12	10	45	Bottom			59			Drift
560	6:37:42	2 Sep 92	N2460637.42	-12	10	45	Bottom			59			Drift
561	6:38:13	2 Sep 92	N2460638.13	-10	11	45	Bottom			59			Drift
562	6:38:46	2 Sep 92	N2460638.46	-10	11	45	Bottom			59			Drift
563	6:45:16	2 Sep 92	N2460645.16	-14	88	6	Bow		7	59	X		
564	6:45:48	2 Sep 92	N2460645.48	-12	58	52	Side			59			Backing
565	6:49:40	2 Sep 92	N2460649.40	-16	82	32	Bow		6	59	X		
566	6:54:50	2 Sep 92	N2460654.50	-11	27	49	Side			59			Backing
567	6:56:14	2 Sep 92	N2460656.14	-10	34	16	Bow		3	59	X		Long
568	10:25:27	2 Sep 92	N2461025.27	-26	16	59	Transom			59			Drift
569	10:29:04	2 Sep 92	N2461029.04	-26	89	52	Side			59			
570	10:30:57	2 Sep 92	N2461030.57	-26	47	51	Side			59			
571	10:32:27	2 Sep 92	N2461032.27	-25	27	49	Side	Bow	7	59			2
572	10:35:02	2 Sep 92	N2461035.02	-10	90	6	Bow	Side	6	59	2X	Dn2	
573	10:37:18	2 Sep 92	N2461037.18	-11	67	28	Bow		7	59	X		2
574	10:38:18	2 Sep 92	N2461038.18	-11	84	40	Bow	Side	3	59			Long
575	10:41:18	2 Sep 92	N2461041.18	-9	97	26	Bow	Side	1	59			Spiky Event
576	10:43:38	2 Sep 92	N2461043.38	-8	25	53	Side			59			Backing
577	10:44:14	2 Sep 92	N2461044.14	-9	70	53	Side			59			Backing
578	10:44:54	2 Sep 92	N2461044.54	-10	124	53	Side			59			2, Excellent
579	10:45:29	2 Sep 92	N2461045.29	-9	22	53	Side	Bow	7	59	X		
580	10:46:44	2 Sep 92	N2461046.44	-9	46	49	Side	Bow	7	59	X		Long
581	10:48:09	2 Sep 92	N2461048.09	-10	83	51	Side	Bow	5	59			2
582	10:49:44	2 Sep 92	N2461049.44	-9	45	43	Bottom			59	3X		Excellent
583	10:58:18	2 Sep 92	N2461058.18	-9	73	4	Bow		5	59			
584	10:59:16	2 Sep 92	N2461059.16	-9	50	5	Bow		5	59	X		
585	11:01:06	2 Sep 92	N2461101.06	-8	82	3	Bow		7	59			2
586	11:03:33	2 Sep 92	N2461103.33	-9	45	14	Bow		7	59	X		3
587	11:04:35	2 Sep 92	N2461104.35	-9	83	22	Bow		7	59	X		3
588	11:05:37	2 Sep 92	N2461105.37	-8	13	28	Bow	Side	5	59	X		
589	11:07:14	2 Sep 92	N2461107.14	-11	128	4	Bow		7	59	X		
590	11:08:01	2 Sep 92	N2461108.01	-9	11	50	Side			59			2
591	11:10:34	2 Sep 92	N2461110.34	-8	18	50	Side			59			
592	11:12:51	2 Sep 92	N2461112.51	-9	106	15	Bow		6	59	2X	Dn1	2
593	11:14:42	2 Sep 92	N2461114.42	-9	59	28	Bow		7	59	X		2
594	11:16:07	2 Sep 92	N2461116.07	-7	53	28	Bow		7	59	X		
595	11:16:42	2 Sep 92	N2461116.42	-8	75	1	Bow		7	59			3
596	11:18:19	2 Sep 92	N2461118.19	-11	92	28	Bow	Bottom	7	59	X		
597	11:21:11	2 Sep 92	N2461121.11	-9	56	41	Bow		7	59			
598	11:23:10	2 Sep 92	N2461123.10	-10	53	1	Bow		7	59	X		Long
599	11:25:47	2 Sep 92	N2461125.47	-8	45	40	Bow	Side	7	59	X		Long
600	11:27:59	2 Sep 92	N2461127.59	-9	40	28	Bow		7	59	X		2

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
601	12:03:13	2 Sep 92	N2461203.13	-8	10	45	Bottom			59			Drift
602	12:03:55	2 Sep 92	N2461203.55	-10	10	45	Bottom			59			Drift
603	12:22:24	2 Sep 92	N2461222.24	-9	9	45	Bottom			59			Drift
604	12:22:55	2 Sep 92	N2461222.55	-9	10	45	Bottom			59			Drift
605	12:23:27	2 Sep 92	N2461223.27	-10	10	45	Bottom			59			Drift
606	12:23:57	2 Sep 92	N2461223.57	-9	10	45	Bottom			59			Drift
607	12:24:26	2 Sep 92	N2461224.26	-10	10	45	Bottom			59			Drift
608	12:24:56	2 Sep 92	N2461224.56	-10	10	45	Bottom			59			Drift
609	12:25:29	2 Sep 92	N2461225.29	-9	10	45	Bottom			59			Drift
610	12:26:03	2 Sep 92	N2461226.03	-10	9	45	Bottom			59			Drift
611	13:00:11	2 Sep 92	N2461300.11	-13	8	45	Bottom			59			Drift
612	20:39:48	2 Sep 92	N2462039.48	-11	72	49	Side			59			
613	20:42:18	2 Sep 92	N2462042.18	-10	51	7	Bow		5	59			
614	21:09:16	2 Sep 92	N2462109.16	-13	16	50	Side			59			
615	22:13:58	2 Sep 92	N2462213.58	-22	67	4	Bow		7	59	X		
616	22:24:42	2 Sep 92	N2462224.42	-21	38	16	Bow		7	59	X		
617	22:28:42	2 Sep 92	N2462228.42	-21	52	49	Side	Bow	7	59			
618	22:29:57	2 Sep 92	N2462229.57	-21	68	51	Side			59			
619	22:35:39	2 Sep 92	N2462235.39	-20	46	1	Bow		7	59			
620	22:38:05	2 Sep 92	N2462238.05	-19	57	2	Bow		7	59			
621	22:49:43	2 Sep 92	N2462249.43	-18	48	3	Bow		7	59	X		
622	22:54:55	2 Sep 92	N2462254.55	-22	206	40	Bow		7	59	X	Dn1	
623	22:58:04	2 Sep 92	N2462258.04	-17	48	16	Bow		7	59	X		
624	23:09:48	2 Sep 92	N2462309.48	-16	28	49	Side	Bow	6	59			
625	23:13:17	2 Sep 92	N2462313.17	-16	41	28	Bow		7	59	X		
626	23:17:22	2 Sep 92	N2462317.22	-15	20	49	Side	Bow	3	59	X		2
627	23:24:27	2 Sep 92	N2462324.27	-15	41	53	Side	Bow	3	59	X		
628	23:31:27	2 Sep 92	N2462331.27	-15	30	53	Side	Bow	5	59			
629	23:37:00	2 Sep 92	N2462337.00	-14	105	38	Bow		7	59	X		
630	23:38:52	2 Sep 92	N2462338.52	-15	54	50	Side			59			2
631	23:40:46	2 Sep 92	N2462340.46	-16	72	35	Bow		6	59	X		
632	23:42:59	2 Sep 92	N2462342.59	-17	47	15	Bow		7	59	2X	Dn1	2
633	23:47:43	2 Sep 92	N2462347.43	-19	51	53	Side			59			
634	23:50:02	2 Sep 92	N2462350.02	-21	28	51	Side			59			
635	23:51:03	2 Sep 92	N2462351.03	-21	76	4	Bow		7	59	X		
636	23:55:12	2 Sep 92	N2462355.12	-23	31	4	Bow	Side	7	59	X		2
637	23:59:07	2 Sep 92	N2462359.07	-84	65	28	Bow	Side	6	59	X		2
638	0:01:00	3 Sep 92	N2470001.00	-24	150	16	Bow		7	59			Excellent
639	0:03:17	3 Sep 92	N2470003.17	-23	46	34	Bow		7	59	X		
640	0:04:34	3 Sep 92	N2470004.34	-23	50	10	Bow		5	59	X		
641	0:05:24	3 Sep 92	N2470005.24	-23	114	16	Bow		6	59	X		
642	0:06:38	3 Sep 92	N2470006.38	-23	62	10	Bow		5	59		Dn1	Card 2 partial shift
643	0:08:30	3 Sep 92	N2470008.30	-23	33	49	Side	Bow, Btm	5	59			
644	0:10:13	3 Sep 92	N2470010.13	-23	78	28	Bow		7	59	X		
645	0:11:19	3 Sep 92	N2470011.19	-32	94	1	Bow	Bottom	7	59	X		
646	0:13:55	3 Sep 92	N2470013.55	-22	49	16	Bow		7	59	15X		
647	0:14:41	3 Sep 92	N2470014.41	-22	67	1	Bow		6	59			
648	0:15:34	3 Sep 92	N2470015.34	-22	26	18	Bow	Side	5	59			
649	0:17:12	3 Sep 92	N2470017.12	-22	57	56	Bow		3	59	X		Trig. by Trans. Spike
650	0:17:59	3 Sep 92	N2470017.59	-21	58	1	Bow		2	59	X		

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Continued)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
651	0:18:47	3 Sep 92	N2470018.47	-22	63	1	Bow		7	59	X		3
652	0:22:09	3 Sep 92	N2470022.09	-21	34	1	Bow		6	59		Dn1	2
653	0:22:56	3 Sep 92	N2470022.56	-21	102	2	Bow		7	59			
654	0:26:17	3 Sep 92	N2470026.17	-21	41	16	Bow		7	59			2
655	0:27:30	3 Sep 92	N2470027.30	-20	77	4	Bow		5	59	X		
656	0:29:13	3 Sep 92	N2470029.13	-20	23	49	Side			59			
657	0:31:18	3 Sep 92	N2470031.18	-20	47	50	Side			59			
658	1:08:06	3 Sep 92	N2470108.06	-18	25	59	Transom			59			Long Excel
659	1:12:24	3 Sep 92	N2470112.24	-18	52	49	Side			59			
660	1:13:44	3 Sep 92	N2470113.44	-18	34	50	Side			59			
661	1:15:12	3 Sep 92	N2470115.12	-18	41	23	Bow		3	59	X		2
662	1:17:50	3 Sep 92	N2470117.50	-18	50	49	Side			59	2X		
663	1:19:02	3 Sep 92	N2470119.02	-18	32	10	Bow		5	59	X		2
664	1:19:49	3 Sep 92	N2470119.49	-18	65	34	Bow		7	59			
665	1:20:41	3 Sep 92	N2470120.41	-17	64	34	Bow	Side	7	59			
666	1:21:17	3 Sep 92	N2470121.17	-17	82	40	Bow		7	59			
667	1:27:02	3 Sep 92	N2470127.02	-17	45	9	Bow	Bottom	7	59	X		
668	1:29:23	3 Sep 92	N2470129.23	-18	60	10	Bow		7	59			
669	11:31:02	6 Sep 92	N2501131.02	-10	25	52	Side	Bow	4	59	X		2
670	14:04:41	6 Sep 92	N2501404.41	-23	95	56	Side			59	X		Trig. by Trans. Spike
671	14:05:18	6 Sep 92	N2501405.18	-12	30	49	Side			59			
672	14:10:54	6 Sep 92	N2501410.54	-12	133	56	Side			59			2,Trig by Trans Spike
673	14:11:47	6 Sep 92	N2501411.47	-16	30	50	Side	Bow	1	59	X		
674	15:33:15	6 Sep 92	N2501533.15	-13	9	58	Transom			59			Drift
675	18:16:23	6 Sep 92	N2501816.23	-16	71	22	Bow		7	59	X	Dn1	3
676	18:57:43	6 Sep 92	N2501857.43	-14	20	7	Bow		2	59	X		
677	18:59:51	6 Sep 92	N2501859.51	-15	38	4	Bow		7	59	X		2
678	20:23:44	6 Sep 92	N2502023.44	-13	17	50	Side			59			
679	20:25:16	6 Sep 92	N2502025.16	-13	41	49	Side			59			
680	0:34:13	7 Sep 92	N2510034.13	-10	39	53	Side			59			Backing
681	0:40:42	7 Sep 92	N2510040.42	-11	45	56	Bow	Side	6	59	X		Trig. by Trans. Spike
682	0:41:48	7 Sep 92	N2510041.48	-13	29	49	Side			59			
683	0:42:21	7 Sep 92	N2510042.21	-12	44	50	Side	Bow	5	59	2X	Dn2	
684	0:43:37	7 Sep 92	N2510043.37	-12	87	53	Side	Bow	4	59			2
685	0:44:16	7 Sep 92	N2510044.16	-12	81	21	Bow	Side	7	59	X	Dn1	
686	0:48:33	7 Sep 92	N2510048.33	-14	33	21	Bow	Side	4	59	X		
687	1:54:43	7 Sep 92	N2510154.43	-12	23	7	Bow		7	59	X		
688	13:43:31	7 Sep 92	N2511343.31	-11	38	7	Bow		5	59	X		2
689	20:08:59	7 Sep 92	N2512008.59	-18	56	4	Bow		3	59	X		
690	20:13:29	7 Sep 92	N2512013.29	-19	16	50	Side			59			Backing
691	14:06:05	8 Sep 92	N2521406.05	-15	22	25	Bow		5	59			
692	16:26:13	8 Sep 92	N2521626.13	-19	19	16	Bow		4	59	X		2
693	16:33:57	8 Sep 92	N2521633.57	-20	19	7	Bow	Transom	6	59	X		3
694	16:34:40	8 Sep 92	N2521634.40	-20	18	56	Bow		7	59	X		3,Trig by Trans Spike
695	16:35:33	8 Sep 92	N2521635.33	-20	21	8	Bow		7	59	X		3
696	16:36:05	8 Sep 92	N2521636.05	-20	46	49	Side	Bow	7	59	X		3
697	16:36:39	8 Sep 92	N2521636.39	-25	79	49	Side	Bow	4	59	X	Dn1	2
698	16:37:10	8 Sep 92	N2521637.10	-26	54	52	Side	Bow	5	59	X	Dn1	
699	16:37:45	8 Sep 92	N2521637.45	-20	41	22	Bow	Side	7	59	X	Dn1	3
700	16:38:16	8 Sep 92	N2521638.16	-20	61	56	Bow	Side	4	59	X	Dn1	Trig. by Trans. Spike

Table D-1. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Raw Data Records by Day (Concluded)

Record No.	Time GMT	Date	Raw Data File Name	All Channels Min & Max		Max Chan	Primary Location	Secondary Locations	No. Bow Frames	Chans Active	Chan Jump	Chan Shift	Comments
				(με)	(με)	(με)							
701	16:38:49	8 Sep 92	N2521638.49	-20	88	50	Side	Bow	3	59	X	Dn3	2
702	16:40:22	8 Sep 92	N2521640.22	-20	42	50	Side	Bow	4	59			
703	16:40:48	8 Sep 92	N2521640.48	-20	48	56	Bow	Side	5	59			Trig. by Trans. Spike
704	18:40:31	8 Sep 92	N2521840.31	-18	74	49	Side			59			
705	18:41:13	8 Sep 92	N2521841.13	-18	47	50	Side	Bow	2	59	X		
706	18:41:54	8 Sep 92	N2521841.54	-18	42	49	Side	Bow	2	59			
707	18:44:01	8 Sep 92	N2521844.01	-18	22	22	Bow		6	59	X		
708	18:44:35	8 Sep 92	N2521844.35	-18	42	49	Side	Bow	3	59	X	Dn1	
709	18:45:41	8 Sep 92	N2521845.41	-18	32	49	Side	Bow	2	59	X		
710	18:46:19	8 Sep 92	N2521846.19	-18	19	7	Bow		3	59	X		2
711	18:47:24	8 Sep 92	N2521847.24	-18	18	21	Bow		4	59	X	Dn2	3. Card 2 partial shift
712	19:24:48	8 Sep 92	N2521924.48	-17	22	49	Side	Bow	3	59	X		2
713	19:37:05	8 Sep 92	N2521937.05	-19	21	54	Side	Bow	4	59	X		2
714	19:39:05	8 Sep 92	N2521939.05	-20	35	49	Side	Bow	1	59	X		
715	20:18:05	8 Sep 92	N2522018.05	-17	25	7	Bow		3	59	X		
716	13:54:43	9 Sep 92	N2531354.43	-10	86	49	Side			59			Long
717	14:15:34	9 Sep 92	N2531415.34	-9	32	21	Bow		5	59	X		3
718	14:16:57	9 Sep 92	N2531416.57	-14	22	7	Bow		6	59	X		3
719	14:18:19	9 Sep 92	N2531418.19	-10	18	7	Bow		7	59	X		2
720	15:34:10	9 Sep 92	N2531534.10	-13	22	7	Bow		5	59	X		2

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
1	1	15:57:34	28 Aug 92	R2411557.34B	N2411557.34	Bow	7	59	129	23	
2	2	16:12:02	28 Aug 92	R2411612.02B	N2411612.02	Bow	3	59	158	29	
3	2	16:12:02	28 Aug 92	R2411612.02T	N2411612.02	Transom		59	37	6	Possible Milling
4	3	16:14:56	28 Aug 92	R2411614.56B	N2411614.56	Bow	7	59	568	109	
5	4	16:22:45	28 Aug 92	R2411622.45B	N2411622.45	Bow	7	59	735	178	Excellent
6	5	16:28:26	28 Aug 92	R2411628.26S	N2411628.26	Side		59	154	51	Excellent
7	6	16:30:22	28 Aug 92	R2411630.22B	N2411630.22	Bow	7	59	176	48	
8	7	16:39:27	28 Aug 92	R2411639.27B	N2411639.27	Bow	6	59	490	84	
9	8	16:57:22	28 Aug 92	R2411657.22B	N2411657.22	Bow	7	59	361	54	
10	9	17:07:50	28 Aug 92	R2411707.50B	N2411707.50	Bow	4	59	435	65	
11	10	21:11:46	28 Aug 92	R2412111.46B	N2412111.46	Bow	4	59	289	43	
12	11	23:54:01	28 Aug 92	R2412354.01B	N2412354.01	Bow	3	16	323	62	
13	12	0:17:39	29 Aug 92	R2420017.39B	N2420017.39	Bow	3	16	269	47	
14	13	0:24:46	29 Aug 92	R2420024.46B	N2420024.46	Bow	3	16	288	74	
15	14	1:27:16	29 Aug 92	R2420127.16B	N2420127.16	Bow	3	16	191	47	
16	15	1:50:55	29 Aug 92	R2420150.55B	N2420150.55	Bow	3	16	213	44	
17	16	2:06:33	29 Aug 92	R2420206.33B	N2420206.33	Bow	3	16	233	52	
18	17	2:24:35	29 Aug 92	R2420224.35B	N2420224.35	Bow	3	16	240	43	
19	18	2:32:27	29 Aug 92	R2420232.27B	N2420232.27	Bow	3	16	245	55	
20	19	2:41:42	29 Aug 92	R2420241.42B	N2420241.42	Bow	3	16	454	125	
21	20	13:22:14	29 Aug 92	R2421322.14B	N2421322.14	Bow	3	16	164	51	
22	21	13:43:37	29 Aug 92	R2421343.37B	N2421343.37	Bow	3	16	130	61	
23	22	13:44:36	29 Aug 92	R2421344.36B	N2421344.36	Bow	3	16	436	163	
24	23	13:49:02	29 Aug 92	R2421349.02B	N2421349.02	Bow	3	16	239	61	
25	24	14:20:41	29 Aug 92	R2421420.41B	N2421420.41	Bow	4	59	359	91	
26	26	14:23:20	29 Aug 92	R2421423.20B	N2421423.20	Bow	7	59	324	168	Long
27	31	14:29:00	29 Aug 92	R2421429.00B	N2421429.00	Bow	3	59	66	15	
28	33	16:23:45	29 Aug 92	R2421623.45B	N2421623.45	Bow	3	16	201	52	
29	34	16:40:28	29 Aug 92	R2421640.28B	N2421640.28	Bow	3	16	139	31	
30	35	2:20:54	30 Aug 92	R2430220.54B	N2430220.54	Bow	3	16	210	43	
31	36	2:31:36	30 Aug 92	R2430231.36B	N2430231.36	Bow	3	16	201	52	
32	37	2:41:24	30 Aug 92	R2430241.24B	N2430241.24	Bow	3	16	198	55	
33	38	2:44:00	30 Aug 92	R2430244.00B	N2430244.00	Bow	3	16	144	28	
34	39	2:48:24	30 Aug 92	R2430248.24B	N2430248.24	Bow	3	16	169	34	Long
35	40	2:49:48	30 Aug 92	R2430249.48B	N2430249.48	Bow	3	16	207	43	
36	41	3:29:44	30 Aug 92	R2430329.44B	N2430329.44	Bow	3	16	252	46	
37	42	4:22:07	30 Aug 92	R2430422.07B	N2430422.07	Bow	3	16	578	93	
38	43	4:37:43	30 Aug 92	R2430437.43B	N2430437.43	Bow	7	59	158	47	
39	44	4:41:13	30 Aug 92	R2430441.13S	N2430441.13	Side		59	219	64	Excellent
40	45	5:05:18	30 Aug 92	R2430505.18B	N2430505.18	Bow	7	59	179	32	
41	45	5:05:18	30 Aug 92	R2430505.18S	N2430505.18	Side		59	27	4	
42	46	5:22:24	30 Aug 92	R2430522.24S	N2430522.24	Side		59	87	13	
43	47	6:09:12	30 Aug 92	R2430609.12S	N2430609.12	Side		59	79	13	
44	48	6:26:07	30 Aug 92	R2430626.07S	N2430626.07	Side		59	146	22	
45	49	6:35:33	30 Aug 92	R2430635.33B	N2430635.33	Bow	7	59	203	34	
46	50	6:52:43	30 Aug 92	R2430652.43B	N2430652.43	Bow	7	59	182	59	
47	51	6:59:04	30 Aug 92	R2430659.04B	N2430659.04	Bow	4	59	105	27	2
48	52	7:00:38	30 Aug 92	R2430700.38B	N2430700.38	Bow	7	59	255	61	Excellent
49	53	7:04:10	30 Aug 92	R2430704.10B	N2430704.10	Bow	6	59	277	62	
50	54	7:08:33	30 Aug 92	R2430708.33S	N2430708.33	Side		59	144	33	Excellent

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
51	55	7:15:53	30 Aug 92	R2430715.53B	N2430715.53	Bow	6	59	118	39	
52	56	7:16:38	30 Aug 92	R2430716.38B	N2430716.38	Bow	6	59	195	44	
53	57	7:40:14	30 Aug 92	R2430740.14S	N2430740.14	Side		59	88	12	
54	58	7:43:08	30 Aug 92	R2430743.08B	N2430743.08	Bow	7	59	213	108	2
55	59	8:01:30	30 Aug 92	R2430801.30B	N2430801.30	Bow	3	16	188	32	
56	60	8:06:31	30 Aug 92	R2430806.31B	N2430806.31	Bow	3	16	121	29	
57	61	8:10:33	30 Aug 92	R2430810.33B	N2430810.33	Bow	3	16	233	46	
58	62	8:22:00	30 Aug 92	R2430822.00B	N2430822.00	Bow	3	16	419	89	
59	63	8:24:12	30 Aug 92	R2430824.12B	N2430824.12	Bow	3	16	329	66	
60	64	8:31:04	30 Aug 92	R2430831.04B	N2430831.04	Bow	3	16	425	86	
61	65	8:50:07	30 Aug 92	R2430850.07B	N2430850.07	Bow	3	16	152	35	
62	66	8:50:40	30 Aug 92	R2430850.40B	N2430850.40	Bow	3	16	295	87	
63	67	8:53:02	30 Aug 92	R2430853.02B	N2430853.02	Bow	3	16	162	53	
64	68	8:58:08	30 Aug 92	R2430858.08B	N2430858.08	Bow	3	16	217	51	
65	69	8:58:48	30 Aug 92	R2430858.48B	N2430858.48	Bow	3	16	459	97	
66	70	9:01:54	30 Aug 92	R2430901.54B	N2430901.54	Bow	3	16	65	17	
67	71	9:24:03	30 Aug 92	R2430924.03B	N2430924.03	Bow	3	16	97	23	Long
68	72	9:26:50	30 Aug 92	R2430926.50B	N2430926.50	Bow	3	16	158	28	
69	73	9:32:29	30 Aug 92	R2430932.29B	N2430932.29	Bow	3	16	69	18	2
70	74	9:37:34	30 Aug 92	R2430937.34B	N2430937.34	Bow	3	16	169	37	
71	75	9:42:17	30 Aug 92	R2430942.17B	N2430942.17	Bow	3	16	168	31	
72	76	9:57:16	30 Aug 92	R2430957.16B	N2430957.16	Bow	3	16	130	36	
73	77	10:27:37	30 Aug 92	R2431027.37B	N2431027.37	Bow	3	16	141	42	2
74	78	10:34:14	30 Aug 92	R2431034.14B	N2431034.14	Bow	3	16	86	29	
75	79	10:39:55	30 Aug 92	R2431039.55B	N2431039.55	Bow	3	16	147	29	
76	80	10:48:46	30 Aug 92	R2431048.46B	N2431048.46	Bow	3	16	121	49	
77	81	10:50:09	30 Aug 92	R2431050.09B	N2431050.09	Bow	3	16	227	77	Long
78	82	10:56:55	30 Aug 92	R2431056.55B	N2431056.55	Bow	3	16	98	28	
79	83	10:58:54	30 Aug 92	R2431058.54B	N2431058.54	Bow	3	16	232	73	
80	84	11:05:05	30 Aug 92	R2431105.05B	N2431105.05	Bow	3	16	123	30	2
81	85	12:55:32	30 Aug 92	R2431255.32B	N2431255.32	Bow	3	16	75	21	3
82	86	13:56:52	30 Aug 92	R2431356.52B	N2431356.52	Bow	3	16	390	110	Very Long Impact
83	87	13:57:22	30 Aug 92	R2431357.22B	N2431357.22	Bow	3	16	314	74	Same Imp
84	88	13:57:49	30 Aug 92	R2431357.49B	N2431357.49	Bow	3	16	283	68	Same Imp
85	89	13:58:18	30 Aug 92	R2431358.18B	N2431358.18	Bow	3	16	254	61	Same Imp
86	90	13:58:48	30 Aug 92	R2431358.48B	N2431358.48	Bow	3	16	249	62	Same Imp
87	91	13:59:18	30 Aug 92	R2431359.18B	N2431359.18	Bow	3	16	232	56	Same Imp
88	92	13:59:47	30 Aug 92	R2431359.47B	N2431359.47	Bow	3	16	229	56	Same Imp
89	93	14:00:19	30 Aug 92	R2431400.19B	N2431400.19	Bow	3	16	226	59	Same Imp
90	94	14:00:52	30 Aug 92	R2431400.52B	N2431400.52	Bow	3	16	223	52	Same Imp
91	95	14:01:18	30 Aug 92	R2431401.18B	N2431401.18	Bow	3	16	215	51	Same Imp
92	96	14:01:46	30 Aug 92	R2431401.46B	N2431401.46	Bow	3	16	213	50	Same Imp
93	97	14:02:14	30 Aug 92	R2431402.14B	N2431402.14	Bow	3	16	224	55	Same Imp
94	98	14:05:31	30 Aug 92	R2431405.31B	N2431405.31	Bow	3	16	106	24	
95	99	14:10:05	30 Aug 92	R2431410.05B	N2431410.05	Bow	3	16	287	86	
96	100	14:10:38	30 Aug 92	R2431410.38B	N2431410.38	Bow	3	16	77	28	Many
97	101	14:12:15	30 Aug 92	R2431412.15B	N2431412.15	Bow	3	16	150	26	
98	102	14:13:52	30 Aug 92	R2431413.52B	N2431413.52	Bow	3	16	504	133	Excellent
99	103	14:31:25	30 Aug 92	R2431431.25B	N2431431.25	Bow	3	16	266	76	
100	104	14:32:00	30 Aug 92	R2431432.00B	N2431432.00	Bow	3	16	176	32	

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
101	105	14:48:16	30 Aug 92	R2431448.16B	N2431448.16	Bow	3	16	556	108	Excellent
102	106	14:50:13	30 Aug 92	R2431450.13B	N2431450.13	Bow	3	16	154	34	2
103	107	14:55:17	30 Aug 92	R2431455.17B	N2431455.17	Bow	3	16	184	52	
104	108	15:10:09	30 Aug 92	R2431510.09B	N2431510.09	Bow	3	16	227	53	
105	109	15:19:10	30 Aug 92	R2431519.10B	N2431519.10	Bow	1	16	75	11	
106	110	15:25:53	30 Aug 92	R2431525.53B	N2431525.53	Bow	3	16	131	27	
107	111	15:35:16	30 Aug 92	R2431535.16B	N2431535.16	Bow	3	16	123	35	3
108	112	16:15:49	30 Aug 92	R2431615.49B	N2431615.49	Bow	3	16	180	49	
109	113	16:24:07	30 Aug 92	R2431624.07B	N2431624.07	Bow	3	16	78	19	
110	114	16:29:58	30 Aug 92	R2431629.58B	N2431629.58	Bow	3	16	162	54	3
111	115	16:53:10	30 Aug 92	R2431653.10B	N2431653.10	Bow	3	16	207	58	2
112	116	16:53:53	30 Aug 92	R2431653.53B	N2431653.53	Bow	3	16	109	39	
113	117	16:57:14	30 Aug 92	R2431657.14B	N2431657.14	Bow	3	16	192	49	
114	118	16:57:45	30 Aug 92	R2431657.45B	N2431657.45	Bow	3	16	65	20	Long
115	119	17:25:47	30 Aug 92	R2431725.47B	N2431725.47	Bow	3	16	83	18	
116	120	17:28:50	30 Aug 92	R2431728.50B	N2431728.50	Bow	3	16	148	43	2
117	121	17:31:47	30 Aug 92	R2431731.47B	N2431731.47	Bow	3	16	162	24	
118	122	17:34:33	30 Aug 92	R2431734.33B	N2431734.33	Bow	3	16	116	21	
119	123	17:44:01	30 Aug 92	R2431744.01B	N2431744.01	Bow	3	16	140	45	
120	124	17:52:15	30 Aug 92	R2431752.15B	N2431752.15	Bow	3	16	291	51	3
121	125	17:53:16	30 Aug 92	R2431753.16B	N2431753.16	Bow	3	16	348	66	
122	126	17:53:52	30 Aug 92	R2431753.52B	N2431753.52	Bow	3	16	128	31	
123	127	17:54:24	30 Aug 92	R2431754.24B	N2431754.24	Bow	3	16	111	21	
124	128	17:56:05	30 Aug 92	R2431756.05B	N2431756.05	Bow	3	16	123	20	
125	129	17:58:53	30 Aug 92	R2431758.53B	N2431758.53	Bow	3	16	155	39	
126	130	18:09:34	30 Aug 92	R2431809.34B	N2431809.34	Bow	3	16	66	25	2
127	131	18:12:22	30 Aug 92	R2431812.22B	N2431812.22	Bow	3	16	208	47	2
128	132	18:13:12	30 Aug 92	R2431813.12B	N2431813.12	Bow	3	16	55	24	
129	133	18:15:05	30 Aug 92	R2431815.05B	N2431815.05	Bow	3	16	106	27	
130	134	18:21:01	30 Aug 92	R2431821.01B	N2431821.01	Bow	3	16	458	125	Excellent
131	135	18:32:27	30 Aug 92	R2431832.27B	N2431832.27	Bow	3	16	195	37	
132	136	18:35:06	30 Aug 92	R2431835.06B	N2431835.06	Bow	3	16	90	13	2
133	137	18:35:52	30 Aug 92	R2431835.52B	N2431835.52	Bow	3	16	111	34	
134	138	18:38:50	30 Aug 92	R2431838.50B	N2431838.50	Bow	3	16	120	26	
135	139	18:44:32	30 Aug 92	R2431844.32B	N2431844.32	Bow	3	16	90	28	
136	140	18:56:34	30 Aug 92	R2431856.34B	N2431856.34	Bow	3	16	138	42	Long
137	141	19:02:29	30 Aug 92	R2431902.29B	N2431902.29	Bow	3	16	222	59	
138	142	19:06:52	30 Aug 92	R2431906.52B	N2431906.52	Bow	3	16	588	123	Excellent
139	143	19:07:40	30 Aug 92	R2431907.40B	N2431907.40	Bow	2	16	130	22	
140	144	19:10:10	30 Aug 92	R2431910.10B	N2431910.10	Bow	3	16	174	41	3
141	145	19:13:34	30 Aug 92	R2431913.34B	N2431913.34	Bow	3	16	196	29	2
142	146	19:21:34	30 Aug 92	R2431921.34B	N2431921.34	Bow	3	16	60	13	5
143	147	19:37:41	30 Aug 92	R2431937.41B	N2431937.41	Bow	3	16	105	17	
144	148	19:48:18	30 Aug 92	R2431948.18B	N2431948.18	Bow	3	16	114	43	
145	149	19:49:49	30 Aug 92	R2431949.49B	N2431949.49	Bow	3	16	304	86	
146	150	19:57:00	30 Aug 92	R2431957.00B	N2431957.00	Bow	3	16	242	49	
147	151	19:58:41	30 Aug 92	R2431958.41B	N2431958.41	Bow	3	16	126	19	
148	152	20:18:11	30 Aug 92	R2432018.11B	N2432018.11	Bow	3	16	97	14	
149	153	20:49:22	30 Aug 92	R2432049.22B	N2432049.22	Bow	3	16	147	36	
150	154	21:05:36	30 Aug 92	R2432105.36B	N2432105.36	Bow	3	16	70	14	3

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
151	155	21:14:23	30 Aug 92	R2432114.23B	N2432114.23	Bow	3	16	67	19	2
152	156	21:17:16	30 Aug 92	R2432117.16B	N2432117.16	Bow	3	16	178	36	3
153	157	21:26:53	30 Aug 92	R2432126.53B	N2432126.53	Bow	3	16	62	14	Backing
154	158	21:33:52	30 Aug 92	R2432133.52B	N2432133.52	Bow	3	16	84	13	
155	159	21:36:31	30 Aug 92	R2432136.31B	N2432136.31	Bow	3	16	403	62	
156	160	21:38:35	30 Aug 92	R2432138.35B	N2432138.35	Bow	3	16	142	31	
157	161	22:40:10	30 Aug 92	R2432240.10B	N2432240.10	Bow	3	16	262	44	
158	162	22:40:45	30 Aug 92	R2432240.45B	N2432240.45	Bow	3	16	79	16	Long
159	163	23:33:27	30 Aug 92	R2432333.27B	N2432333.27	Bow	3	16	133	23	
160	164	23:37:02	30 Aug 92	R2432337.02B	N2432337.02	Bow	3	16	270	42	2
161	165	23:39:29	30 Aug 92	R2432339.29B	N2432339.29	Bow	3	16	111	24	
162	166	23:44:12	30 Aug 92	R2432344.12B	N2432344.12	Bow	3	16	95	17	
163	167	23:48:55	30 Aug 92	R2432348.55B	N2432348.55	Bow	3	16	147	44	
164	168	23:50:58	30 Aug 92	R2432350.58B	N2432350.58	Bow	3	16	85	17	
165	169	23:59:16	30 Aug 92	R2432359.16B	N2432359.16	Bow	3	16	118	20	
166	170	0:01:19	31 Aug 92	R2440001.19B	N2440001.19	Bow	3	16	90	13	
167	171	0:24:52	31 Aug 92	R2440024.52B	N2440024.52	Bow	3	16	178	44	
168	172	0:37:19	31 Aug 92	R2440037.19B	N2440037.19	Bow	3	16	199	45	
169	173	1:33:58	31 Aug 92	R2440133.58B	N2440133.58	Bow	3	16	131	25	
170	174	1:58:39	31 Aug 92	R2440158.39B	N2440158.39	Bow	3	16	105	21	
171	175	2:06:09	31 Aug 92	R2440206.09B	N2440206.09	Bow	3	16	230	34	
172	176	2:12:40	31 Aug 92	R2440212.40B	N2440212.40	Bow	3	16	89	31	
173	177	2:15:35	31 Aug 92	R2440215.35B	N2440215.35	Bow	3	16	153	36	3
174	178	2:32:40	31 Aug 92	R2440232.40B	N2440232.40	Bow	3	16	103	36	2
175	179	2:36:27	31 Aug 92	R2440236.27B	N2440236.27	Bow	3	16	126	25	2
176	180	2:38:54	31 Aug 92	R2440238.54B	N2440238.54	Bow	3	16	213	32	
177	181	2:43:51	31 Aug 92	R2440243.51B	N2440243.51	Bow	3	16	177	62	
178	182	2:44:24	31 Aug 92	R2440244.24B	N2440244.24	Bow	3	16	213	64	Long
179	183	3:15:21	31 Aug 92	R2440315.21B	N2440315.21	Bow	3	16	152	58	Long
180	184	3:23:55	31 Aug 92	R2440323.55B	N2440323.55	Bow	3	16	227	70	Long
181	185	3:33:19	31 Aug 92	R2440333.19B	N2440333.19	Bow	3	16	98	23	
182	186	3:41:00	31 Aug 92	R2440341.00B	N2440341.00	Bow	3	16	360	68	Long
183	187	4:02:24	31 Aug 92	R2440402.24B	N2440402.24	Bow	3	16	175	37	
184	188	4:23:48	31 Aug 92	R2440423.48B	N2440423.48	Bow	2	16	252	75	2
185	189	4:44:04	31 Aug 92	R2440444.04B	N2440444.04	Bow	3	16	169	39	
186	190	4:50:01	31 Aug 92	R2440450.01B	N2440450.01	Bow	3	16	191	78	
187	191	4:52:40	31 Aug 92	R2440452.40B	N2440452.40	Bow	3	16	123	48	
188	192	5:02:19	31 Aug 92	R2440502.19B	N2440502.19	Bow	3	16	113	34	
189	193	5:52:32	31 Aug 92	R2440552.32B	N2440552.32	Bow	3	16	98	21	
190	194	6:02:30	31 Aug 92	R2440602.30B	N2440602.30	Bow	3	16	147	31	2
191	195	6:19:46	31 Aug 92	R2440619.46B	N2440619.46	Bow	3	16	188	46	2
192	196	6:31:55	31 Aug 92	R2440631.55B	N2440631.55	Bow	3	16	196	30	
193	197	6:40:51	31 Aug 92	R2440640.51B	N2440640.51	Bow	3	16	229	48	
194	198	6:56:03	31 Aug 92	R2440656.03B	N2440656.03	Bow	3	16	185	48	2
195	199	7:02:41	31 Aug 92	R2440702.41B	N2440702.41	Bow	3	16	92	17	Long
196	200	7:12:42	31 Aug 92	R2440712.42B	N2440712.42	Bow	3	16	151	57	Long
197	201	7:15:35	31 Aug 92	R2440715.35B	N2440715.35	Bow	3	16	170	35	
198	202	7:18:40	31 Aug 92	R2440718.40B	N2440718.40	Bow	3	16	229	36	
199	203	7:20:27	31 Aug 92	R2440720.27B	N2440720.27	Bow	3	16	115	27	
200	204	7:22:33	31 Aug 92	R2440722.33B	N2440722.33	Bow	3	16	229	50	

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
201	205	7:37:14	31 Aug 92	R2440737.14B	N2440737.14	Bow	1	16	147	22	Spike
202	206	7:42:25	31 Aug 92	R2440742.25B	N2440742.25	Bow	3	16	307	70	
203	207	7:45:50	31 Aug 92	R2440745.50B	N2440745.50	Bow	3	16	74	24	Long
204	208	7:50:28	31 Aug 92	R2440750.28B	N2440750.28	Bow	3	16	164	38	
205	209	8:08:15	31 Aug 92	R2440808.15B	N2440808.15	Bow	3	16	396	75	
206	210	8:53:37	31 Aug 92	R2440853.37B	N2440853.37	Bow	3	16	95	16	3
207	211	8:56:02	31 Aug 92	R2440856.02B	N2440856.02	Bow	3	16	199	32	Long
208	212	9:13:50	31 Aug 92	R2440913.50B	N2440913.50	Bow	3	16	251	37	Spiky Event
209	213	9:15:28	31 Aug 92	R2440915.28B	N2440915.28	Bow	3	16	187	77	
210	214	9:19:29	31 Aug 92	R2440919.29B	N2440919.29	Bow	3	16	347	64	2
211	215	9:22:33	31 Aug 92	R2440922.33B	N2440922.33	Bow	3	16	107	16	2
212	216	9:25:11	31 Aug 92	R2440925.11B	N2440925.11	Bow	3	16	252	43	
213	217	9:29:13	31 Aug 92	R2440929.13B	N2440929.13	Bow	3	16	104	21	
214	218	9:35:44	31 Aug 92	R2440935.44B	N2440935.44	Bow	3	16	130	32	
215	219	9:45:22	31 Aug 92	R2440945.22B	N2440945.22	Bow	3	16	284	52	
216	220	9:48:45	31 Aug 92	R2440948.45B	N2440948.45	Bow	2	16	112	17	
217	221	9:51:13	31 Aug 92	R2440951.13B	N2440951.13	Bow	3	16	128	25	
218	222	10:02:27	31 Aug 92	R2441002.27B	N2441002.27	Bow	3	16	91	17	
219	223	10:18:30	31 Aug 92	R2441018.30B	N2441018.30	Bow	3	16	148	31	2
220	224	10:23:36	31 Aug 92	R2441023.36B	N2441023.36	Bow	3	16	263	94	
221	225	10:31:31	31 Aug 92	R2441031.31B	N2441031.31	Bow	3	16	335	85	3
222	226	13:25:12	31 Aug 92	R2441325.12B	N2441325.12	Bow	3	16	145	55	Long
223	227	13:31:30	31 Aug 92	R2441331.30B	N2441331.30	Bow	3	16	88	17	2
224	228	13:46:55	31 Aug 92	R2441346.55B	N2441346.55	Bow	3	16	465	96	Excellent
225	229	13:54:54	31 Aug 92	R2441354.54B	N2441354.54	Bow	3	16	192	42	
226	230	13:58:03	31 Aug 92	R2441358.03B	N2441358.03	Bow	3	16	121	24	2
227	231	14:04:40	31 Aug 92	R2441404.40B	N2441404.40	Bow	1	16	117	18	Spiky Event
228	232	14:27:56	31 Aug 92	R2441427.56B	N2441427.56	Bow	3	16	218	89	2
229	233	16:53:09	31 Aug 92	R2441653.09B	N2441653.09	Bow	3	16	302	100	2
230	234	16:56:46	31 Aug 92	R2441656.46B	N2441656.46	Bow	3	16	141	69	
231	235	17:00:45	31 Aug 92	R2441700.45B	N2441700.45	Bow	3	16	230	63	
232	236	17:13:53	31 Aug 92	R2441713.53B	N2441713.53	Bow	3	16	134	33	2
233	237	17:20:29	31 Aug 92	R2441720.29B	N2441720.29	Bow	3	16	149	36	
234	238	17:23:48	31 Aug 92	R2441723.48B	N2441723.48	Bow	3	16	223	56	
235	239	17:35:54	31 Aug 92	R2441735.54B	N2441735.54	Bow	3	16	153	44	
236	240	17:46:13	31 Aug 92	R2441746.13B	N2441746.13	Bow	3	16	159	44	2
237	241	17:50:35	31 Aug 92	R2441750.35B	N2441750.35	Bow	3	16	130	28	
238	242	20:29:55	31 Aug 92	R2442029.55B	N2442029.55	Bow	2	59	154	52	Long - Next
239	243	20:30:22	31 Aug 92	R2442030.22B	N2442030.22	Bow	7	59	153	73	
240	243	20:30:22	31 Aug 92	R2442030.22S	N2442030.22	Side		59	277	54	Excellent
241	244	20:37:36	31 Aug 92	R2442037.36S	N2442037.36	Side		59	573	97	Excellent
242	245	20:43:03	31 Aug 92	R2442043.03T	N2442043.03	Transom		59	73	12	Excellent
243	246	20:45:39	31 Aug 92	R2442045.39B	N2442045.39	Bow	6	59	140	36	2
244	247	20:51:48	31 Aug 92	R2442051.48S	N2442051.48	Side		59	107	19	Excellent
245	248	20:53:29	31 Aug 92	R2442053.29B	N2442053.29	Bow	7	59	278	137	2
246	249	20:55:00	31 Aug 92	R2442055.00S	N2442055.00	Side		59	30	9	Long
247	250	20:56:29	31 Aug 92	R2442056.29S	N2442056.29	Side		59	50	11	2
248	251	20:59:09	31 Aug 92	R2442059.09B	N2442059.09	Bow	7	59	125	66	2
249	251	20:59:09	31 Aug 92	R2442059.09S	N2442059.09	Side		59	47	12	2
250	252	21:00:10	31 Aug 92	R2442100.10B	N2442100.10	Bow	3	59	90	14	Long

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
251	252	21:00:10	31 Aug 92	R2442100.10S	N2442100.10	Side		59	134	17	
252	253	21:07:06	31 Aug 92	R2442107.06T	N2442107.06	Transom		59	31	6	
253	254	21:08:45	31 Aug 92	R2442108.45B	N2442108.45	Bow	7	59	174	37	2
254	254	21:08:45	31 Aug 92	R2442108.45S	N2442108.45	Side		59	96	15	
255	255	21:10:28	31 Aug 92	R2442110.28B	N2442110.28	Bow	7	59	148	41	
256	255	21:10:28	31 Aug 92	R2442110.28S	N2442110.28	Side		59	27	8	
257	256	21:11:32	31 Aug 92	R2442111.32B	N2442111.32	Bow	7	59	142	67	
258	257	21:12:15	31 Aug 92	R2442112.15B	N2442112.15	Bow	6	59	152	25	
259	257	21:12:15	31 Aug 92	R2442112.15S	N2442112.15	Side		59	88	15	Backing
260	258	21:15:16	31 Aug 92	R2442115.16B	N2442115.16	Bow	7	59	148	40	
261	259	21:18:24	31 Aug 92	R2442118.24B	N2442118.24	Bow	4	59	72	23	
262	259	21:18:24	31 Aug 92	R2442118.24S	N2442118.24	Side		59	497	66	2
263	260	21:19:10	31 Aug 92	R2442119.10B	N2442119.10	Bow	4	59	161	57	Long
264	261	21:22:08	31 Aug 92	R2442122.08B	N2442122.08	Bow	7	59	126	31	
265	262	21:23:23	31 Aug 92	R2442123.23B	N2442123.23	Bow	5	59	51	13	
266	262	21:23:23	31 Aug 92	R2442123.23S	N2442123.23	Side		59	53	9	
267	263	21:26:30	31 Aug 92	R2442126.30S	N2442126.30	Side		59	47	12	
268	264	21:27:48	31 Aug 92	R2442127.48B	N2442127.48	Bow	6	59	32	19	
269	264	21:27:48	31 Aug 92	R2442127.48S	N2442127.48	Side		59	55	7	
270	265	21:29:09	31 Aug 92	R2442129.09S	N2442129.09	Side		59	82	12	Backing
271	266	21:29:56	31 Aug 92	R2442129.56B	N2442129.56	Bow	7	59	125	25	
272	266	21:29:56	31 Aug 92	R2442129.56S	N2442129.56	Side		59	44	6	
273	267	21:30:55	31 Aug 92	R2442130.55T	N2442130.55	Transom		59	28	6	
274	268	21:31:38	31 Aug 92	R2442131.38S	N2442131.38	Side		59	12	2	
275	269	21:32:14	31 Aug 92	R2442132.14B	N2442132.14	Bow	6	59	194	37	
276	270	21:37:13	31 Aug 92	R2442137.13T	N2442137.13	Transom		59	15	4	
277	271	21:42:08	31 Aug 92	R2442142.08T	N2442142.08	Transom		59	38	8	
278	272	21:44:13	31 Aug 92	R2442144.13T	N2442144.13	Transom		59	169	36	
279	273	21:46:29	31 Aug 92	R2442146.29T	N2442146.29	Transom		59	124	20	
280	277	21:57:08	31 Aug 92	R2442157.08T	N2442157.08	Transom		59	256	41	Excel., Spike Remvd
281	278	21:58:09	31 Aug 92	R2442158.09B	N2442158.09	Bow	5	59	179	72	
282	279	22:02:04	31 Aug 92	R2442202.04B	N2442202.04	Bow	7	59	181	53	Long
283	281	22:04:33	31 Aug 92	R2442204.33T	N2442204.33	Transom		59	55	9	Milling
284	282	22:05:25	31 Aug 92	R2442205.25B	N2442205.25	Bow	6	59	265	74	
285	283	22:07:49	31 Aug 92	R2442207.49T	N2442207.49	Transom		59	25	6	Long
286	285	22:14:13	31 Aug 92	R2442214.13T	N2442214.13	Transom		59	31	10	Long
287	286	22:29:34	31 Aug 92	R2442229.34B	N2442229.34	Bow	6	59	392	73	2
288	287	22:32:55	31 Aug 92	R2442232.55S	N2442232.55	Side		59	212	27	
289	288	22:36:45	31 Aug 92	R2442236.45B	N2442236.45	Bow	6	59	375	80	
290	289	22:38:44	31 Aug 92	R2442238.44T	N2442238.44	Transom		59	12	2	Neg. Spike
291	292	22:41:45	31 Aug 92	R2442241.45B	N2442241.45	Bow	5	59	74	13	2
292	292	22:41:45	31 Aug 92	R2442241.45S	N2442241.45	Side		59	24	4	
293	295	23:18:31	31 Aug 92	R2442318.31B	N2442318.31	Bow	7	59	253	74	
294	296	23:19:00	31 Aug 92	R2442319.00B	N2442319.00	Bow	7	59	197	107	
295	297	23:27:20	31 Aug 92	R2442327.20S	N2442327.20	Side		59	60	15	
296	299	23:29:44	31 Aug 92	R2442329.44B	N2442329.44	Bow	3	59	59	12	
297	299	23:29:44	31 Aug 92	R2442329.44F	N2442329.44	Bottom		59	82	47	Good
298	300	23:30:14	31 Aug 92	R2442330.14B	N2442330.14	Bow	2	59	87	16	
299	301	23:31:06	31 Aug 92	R2442331.06F	N2442331.06	Bottom		59	37	10	Good, Backing
300	302	23:32:39	31 Aug 92	R2442332.39B	N2442332.39	Bow	3	59	81	18	

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
301	302	23:32:39	31 Aug 92	R2442332.39S	N2442332.39	Side		59	64	12	
302	303	23:35:04	31 Aug 92	R2442335.04B	N2442335.04	Bow	2	59	12	4	Small
303	303	23:35:04	31 Aug 92	R2442335.04S	N2442335.04	Side		59	30	7	
304	305	23:50:19	31 Aug 92	R2442350.19T	N2442350.19	Transom		59	51	10	2
305	306	23:51:07	31 Aug 92	R2442351.07B	N2442351.07	Bow	7	59	103	24	
306	307	23:53:16	31 Aug 92	R2442353.16B	N2442353.16	Bow	7	59	330	114	2, Long
307	308	23:58:36	31 Aug 92	R2442358.36B	N2442358.36	Bow	7	59	619	198	2, Excellent
308	309	0:01:03	1 Sep 92	R2450001.03B	N2450001.03	Bow	7	59	453	236	Excellent
309	310	0:03:16	1 Sep 92	R2450003.16B	N2450003.16	Bow	1	59	143	21	
310	310	0:03:16	1 Sep 92	R2450003.16S	N2450003.16	Side		59	166	40	
311	311	0:04:02	1 Sep 92	R2450004.02B	N2450004.02	Bow	7	59	31	11	
312	311	0:04:02	1 Sep 92	R2450004.02S	N2450004.02	Side		59	35	6	
313	312	0:08:36	1 Sep 92	R2450008.36B	N2450008.36	Bow	4	59	177	43	2
314	313	0:09:51	1 Sep 92	R2450009.51S	N2450009.51	Side		59	69	13	Backing
315	314	0:11:41	1 Sep 92	R2450011.41T	N2450011.41	Transom		59	63	10	
316	315	0:13:53	1 Sep 92	R2450013.53S	N2450013.53	Side		59	99	17	Long
317	316	0:16:03	1 Sep 92	R2450016.03B	N2450016.03	Bow	7	59	291	152	Cusp Failure
318	317	0:16:58	1 Sep 92	R2450016.58S	N2450016.58	Side		59	401	68	Excellent
319	318	0:19:01	1 Sep 92	R2450019.01B	N2450019.01	Bow	7	59	81	52	4
320	319	0:20:14	1 Sep 92	R2450020.14S	N2450020.14	Side		59	110	15	
321	320	0:21:56	1 Sep 92	R2450021.56B	N2450021.56	Bow	7	59	217	61	2
322	321	0:31:02	1 Sep 92	R2450031.02B	N2450031.02	Bow	5	59	313	123	
323	322	0:34:10	1 Sep 92	R2450034.10B	N2450034.10	Bow	7	59	77	27	
324	322	0:34:10	1 Sep 92	R2450034.10S	N2450034.10	Side		59	102	14	
325	323	1:01:42	1 Sep 92	R2450101.42B	N2450101.42	Bow	7	59	71	13	2
326	323	1:01:42	1 Sep 92	R2450101.42S	N2450101.42	Side		59	212	53	3, Good
327	324	1:04:53	1 Sep 92	R2450104.53S	N2450104.53	Side		59	61	12	2
328	325	1:05:27	1 Sep 92	R2450105.27B	N2450105.27	Bow	6	59	40	21	
329	325	1:05:27	1 Sep 92	R2450105.27S	N2450105.27	Side		59	75	14	
330	326	1:06:16	1 Sep 92	R2450106.16S	N2450106.16	Side		59	239	37	Backing
331	327	1:07:30	1 Sep 92	R2450107.30S	N2450107.30	Side		59	51	10	
332	328	1:08:55	1 Sep 92	R2450108.55B	N2450108.55	Bow	4	59	155	31	Long, Backing
333	329	1:10:57	1 Sep 92	R2450110.57S	N2450110.57	Side		59	84	11	2
334	330	1:11:28	1 Sep 92	R2450111.28B	N2450111.28	Bow	7	59	52	40	
335	330	1:11:28	1 Sep 92	R2450111.28S	N2450111.28	Side		59	231	46	
336	331	1:15:30	1 Sep 92	R2450115.30T	N2450115.30	Transom		59	256	41	2, Excellent
337	332	1:16:50	1 Sep 92	R2450116.50B	N2450116.50	Bow	7	59	196	53	Cusp Failure
338	333	1:21:58	1 Sep 92	R2450121.58B	N2450121.58	Bow	7	59	51	18	Spiky Event
339	333	1:21:58	1 Sep 92	R2450121.58S	N2450121.58	Side		59	86	12	3
340	334	1:25:31	1 Sep 92	R2450125.31B	N2450125.31	Bow	4	59	148	40	
341	335	1:31:16	1 Sep 92	R2450131.16B	N2450131.16	Bow	5	59	106	23	
342	336	1:32:32	1 Sep 92	R2450132.32S	N2450132.32	Side		59	23	5	Long
343	337	1:37:03	1 Sep 92	R2450137.03T	N2450137.03	Transom		59	122	20	3, Excellent
344	338	1:38:24	1 Sep 92	R2450138.24B	N2450138.24	Bow	7	59	270	179	2, Long
345	339	1:39:37	1 Sep 92	R2450139.37B	N2450139.37	Bow	4	59	143	52	
346	340	1:41:36	1 Sep 92	R2450141.36B	N2450141.36	Bow	7	59	219	33	3
347	341	1:45:21	1 Sep 92	R2450145.21S	N2450145.21	Side		59	259	34	Long
348	342	10:39:23	1 Sep 92	R2451039.23B	N2451039.23	Bow	7	59	226	81	
349	343	10:42:04	1 Sep 92	R2451042.04B	N2451042.04	Bow	7	59	259	172	Long, Excellent
350	344	10:45:03	1 Sep 92	R2451045.03B	N2451045.03	Bow	5	59	447	147	Excellent

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
351	346	10:56:30	1 Sep 92	R2451056.30T	N2451056.30	Transom		59	75	12	
352	347	10:57:45	1 Sep 92	R2451057.45B	N2451057.45	Bow	2	59	30	7	
353	347	10:57:45	1 Sep 92	R2451057.45S	N2451057.45	Side		59	126	22	
354	348	11:17:27	1 Sep 92	R2451117.27B	N2451117.27	Bow	5	59	116	31	
355	349	11:30:15	1 Sep 92	R2451130.15B	N2451130.15	Bow	5	59	42	10	
356	349	11:30:15	1 Sep 92	R2451130.15S	N2451130.15	Side		59	62	10	
357	350	11:34:12	1 Sep 92	R2451134.12S	N2451134.12	Side		59	92	43	
358	351	11:44:01	1 Sep 92	R2451144.01S	N2451144.01	Side		59	48	10	
359	353	11:55:28	1 Sep 92	R2451155.28T	N2451155.28	Transom		59	130	21	Excellent
360	354	12:00:24	1 Sep 92	R2451200.24S	N2451200.24	Side		59	68	12	3
361	355	12:06:42	1 Sep 92	R2451206.42T	N2451206.42	Transom		59	77	12	Excellent
362	356	12:13:00	1 Sep 92	R2451213.00T	N2451213.00	Transom		59	82	17	Excellent
363	357	14:54:52	1 Sep 92	R2451454.52S	N2451454.52	Side		59	496	123	Excellent
364	358	14:55:26	1 Sep 92	R2451455.26T	N2451455.26	Transom		59	16	4	Long, Milling, Fwd
365	359	14:56:05	1 Sep 92	R2451456.05S	N2451456.05	Side		59	403	52	Excellent
366	360	14:58:49	1 Sep 92	R2451458.49B	N2451458.49	Bow	7	59	249	91	2
367	361	15:08:25	1 Sep 92	R2451508.25S	N2451508.25	Side		59	266	34	
368	362	15:15:18	1 Sep 92	R2451515.18T	N2451515.18	Transom		59	42	7	
369	364	15:21:55	1 Sep 92	R2451521.55B	N2451521.55	Bow	7	59	155	49	2
370	365	15:26:48	1 Sep 92	R2451526.48B	N2451526.48	Bow	7	59	341	94	
371	366	15:35:45	1 Sep 92	R2451535.45B	N2451535.45	Bow	1	59	32	6	Small
372	367	15:39:22	1 Sep 92	R2451539.22B	N2451539.22	Bow	7	59	163	62	4
373	368	16:11:21	1 Sep 92	R2451611.21S	N2451611.21	Side		59	57	8	2, Noisy
374	369	16:11:52	1 Sep 92	R2451611.52B	N2451611.52	Bow	7	59	234	46	
375	369	16:11:52	1 Sep 92	R2451611.52S	N2451611.52	Side		59	338	83	Excellent
376	370	16:15:05	1 Sep 92	R2451615.05B	N2451615.05	Bow	4	59	35	16	Long
377	370	16:15:05	1 Sep 92	R2451615.05S	N2451615.05	Side		59	125	26	Long
378	371	16:16:48	1 Sep 92	R2451616.48S	N2451616.48	Side		59	565	73	2
379	372	16:22:36	1 Sep 92	R2451622.36S	N2451622.36	Side		59	150	23	
380	374	16:26:14	1 Sep 92	R2451626.14S	N2451626.14	Side		59	136	20	
381	375	16:29:11	1 Sep 92	R2451629.11T	N2451629.11	Transom		59	70	11	Excellent
382	376	16:30:12	1 Sep 92	R2451630.12B	N2451630.12	Bow	7	59	137	52	2
383	376	16:30:12	1 Sep 92	R2451630.12F	N2451630.12	Bottom		59	23	8	Neg. Strain
384	377	16:32:26	1 Sep 92	R2451632.26S	N2451632.26	Side		59	49	10	
385	377	16:32:26	1 Sep 92	R2451632.26T	N2451632.26	Transom		59	49	8	Noisy
386	378	16:33:57	1 Sep 92	R2451633.57B	N2451633.57	Bow	7	59	31	10	2, Noisy
387	378	16:33:57	1 Sep 92	R2451633.57S	N2451633.57	Side		59	41	5	
388	379	16:34:50	1 Sep 92	R2451634.50B	N2451634.50	Bow	7	59	106	62	Long
389	380	16:37:11	1 Sep 92	R2451637.11B	N2451637.11	Bow	7	59	52	14	2
390	380	16:37:11	1 Sep 92	R2451637.11S	N2451637.11	Side		59	170	22	
391	381	16:39:23	1 Sep 92	R2451639.23B	N2451639.23	Bow	7	59	172	61	2
392	381	16:39:23	1 Sep 92	R2451639.23S	N2451639.23	Side		59	118	15	
393	382	16:44:14	1 Sep 92	R2451644.14S	N2451644.14	Side		59	96	18	3
394	383	16:53:55	1 Sep 92	R2451653.55B	N2451653.55	Bow	7	59	259	70	
395	383	16:53:55	1 Sep 92	R2451653.55S	N2451653.55	Side		59	667	86	2, Excellent
396	384	16:56:45	1 Sep 92	R2451656.45S	N2451656.45	Side		59	484	62	Excellent
397	385	16:57:21	1 Sep 92	R2451657.21B	N2451657.21	Bow	6	59	47	34	
398	385	16:57:21	1 Sep 92	R2451657.21F	N2451657.21	Bottom		59	26	8	Spiky Event
399	386	17:02:34	1 Sep 92	R2451702.34S	N2451702.34	Side		59	64	11	
400	387	17:05:19	1 Sep 92	R2451705.19B	N2451705.19	Bow	7	59	167	48	2

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
401	388	17:07:40	1 Sep 92	R2451707.40S	N2451707.40	Side		59	519	80	Excellent, Backing
402	389	17:11:29	1 Sep 92	R2451711.29B	N2451711.29	Bow	7	59	296	74	
403	390	17:13:42	1 Sep 92	R2451713.42S	N2451713.42	Side		59	30	11	
404	391	17:14:46	1 Sep 92	R2451714.46B	N2451714.46	Bow	2	59	149	22	
405	391	17:14:46	1 Sep 92	R2451714.46S	N2451714.46	Side		59	715	136	Excellent
406	392	17:16:26	1 Sep 92	R2451716.26B	N2451716.26	Bow	5	59	64	11	
407	392	17:16:26	1 Sep 92	R2451716.26S	N2451716.26	Side		59	132	17	
408	393	17:25:20	1 Sep 92	R2451725.20B	N2451725.20	Bow	7	59	302	71	
409	394	17:27:44	1 Sep 92	R2451727.44B	N2451727.44	Bow	7	59	240	70	2
410	394	17:27:44	1 Sep 92	R2451727.44F	N2451727.44	Bottom		59	39	23	
411	395	17:29:41	1 Sep 92	R2451729.41S	N2451729.41	Side		59	132	26	
412	396	17:30:34	1 Sep 92	R2451730.34S	N2451730.34	Side		59	177	25	
413	397	17:32:08	1 Sep 92	R2451732.08T	N2451732.08	Transom		59	67	11	Spiky Event
414	398	17:33:17	1 Sep 92	R2451733.17B	N2451733.17	Bow	5	59	271	62	
415	399	17:35:52	1 Sep 92	R2451735.52S	N2451735.52	Side		59	137	28	
416	400	17:36:38	1 Sep 92	R2451736.38B	N2451736.38	Bow	2	59	27	6	
417	400	17:36:38	1 Sep 92	R2451736.38T	N2451736.38	Transom		59	26	6	Noisy
418	401	17:38:16	1 Sep 92	R2451738.16B	N2451738.16	Bow	7	59	182	56	
419	402	17:41:27	1 Sep 92	R2451741.27B	N2451741.27	Bow	6	59	33	8	Long
420	402	17:41:27	1 Sep 92	R2451741.27S	N2451741.27	Side		59	61	10	Long
421	403	17:44:16	1 Sep 92	R2451744.16S	N2451744.16	Side		59	43	7	
422	404	17:45:13	1 Sep 92	R2451745.13S	N2451745.13	Side		59	378	71	Excellent, Backing
423	405	17:46:54	1 Sep 92	R2451746.54B	N2451746.54	Bow	7	59	471	125	2, Backing
424	406	17:48:47	1 Sep 92	R2451748.47S	N2451748.47	Side		59	262	68	Excellent
425	407	17:50:13	1 Sep 92	R2451750.13B	N2451750.13	Bow	3	59	243	57	2
426	407	17:50:13	1 Sep 92	R2451750.13T	N2451750.13	Transom		59	29	7	
427	408	17:51:39	1 Sep 92	R2451751.39S	N2451751.39	Side		59	229	61	Long, Backing
428	409	17:53:18	1 Sep 92	R2451753.18B	N2451753.18	Bow	6	59	91	17	2
429	409	17:53:18	1 Sep 92	R2451753.18S	N2451753.18	Side		59	60	13	Spiky Event
430	410	17:54:51	1 Sep 92	R2451754.51S	N2451754.51	Side		59	411	53	Excellent
431	411	17:59:36	1 Sep 92	R2451759.36B	N2451759.36	Bow	3	59	114	38	
432	413	18:05:36	1 Sep 92	R2451805.36B	N2451805.36	Bow	4	59	31	11	
433	413	18:05:36	1 Sep 92	R2451805.36S	N2451805.36	Side		59	230	32	
434	414	18:08:08	1 Sep 92	R2451808.08S	N2451808.08	Side		59	381	50	Excellent
435	415	18:12:31	1 Sep 92	R2451812.31B	N2451812.31	Bow	5	59	201	99	2
436	416	18:14:53	1 Sep 92	R2451814.53B	N2451814.53	Bow	5	59	41	17	2
437	416	18:14:53	1 Sep 92	R2451814.53S	N2451814.53	Side		59	38	5	Spiky Event
438	417	18:17:25	1 Sep 92	R2451817.25B	N2451817.25	Bow	7	59	193	62	
439	418	18:18:25	1 Sep 92	R2451818.25B	N2451818.25	Bow	5	59	38	13	
440	419	18:18:57	1 Sep 92	R2451818.57B	N2451818.57	Bow	6	59	42	20	
441	419	18:18:57	1 Sep 92	R2451818.57S	N2451818.57	Side		59	79	21	2
442	420	18:20:10	1 Sep 92	R2451820.10B	N2451820.10	Bow	7	59	349	73	Excellent
443	421	18:22:40	1 Sep 92	R2451822.40S	N2451822.40	Side		59	219	38	2
444	422	18:23:29	1 Sep 92	R2451823.29B	N2451823.29	Bow	7	59	155	65	2
445	422	18:23:29	1 Sep 92	R2451823.29S	N2451823.29	Side		59	47	9	
446	423	18:26:39	1 Sep 92	R2451826.39B	N2451826.39	Bow	7	59	174	38	3
447	423	18:26:39	1 Sep 92	R2451826.39S	N2451826.39	Side		59	63	8	
448	424	18:27:54	1 Sep 92	R2451827.54S	N2451827.54	Side		59	115	15	
449	424	18:27:54	1 Sep 92	R2451827.54T	N2451827.54	Transom		59	115	18	Spiky Event
450	425	18:29:53	1 Sep 92	R2451829.53T	N2451829.53	Transom		59	29	5	Spiky Event

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
451	426	18:34:41	1 Sep 92	R2451834.41B	N2451834.41	Bow	4	59	81	21	
452	427	18:36:55	1 Sep 92	R2451836.55T	N2451836.55	Transom		59	36	6	
453	428	18:39:18	1 Sep 92	R2451839.18B	N2451839.18	Bow	7	59	129	46	2
454	429	18:40:27	1 Sep 92	R2451840.27S	N2451840.27	Side		59	188	24	3
455	430	18:44:25	1 Sep 92	R2451844.25B	N2451844.25	Bow	7	59	102	32	
456	430	18:44:25	1 Sep 92	R2451844.25S	N2451844.25	Side		59	132	25	2
457	431	18:45:33	1 Sep 92	R2451845.33B	N2451845.33	Bow	7	59	105	49	
458	432	18:47:30	1 Sep 92	R2451847.30B	N2451847.30	Bow	1	59	89	15	Backing
459	432	18:47:30	1 Sep 92	R2451847.30S	N2451847.30	Side		59	195	37	Backing
460	433	18:49:05	1 Sep 92	R2451849.05B	N2451849.05	Bow	7	59	132	38	3
461	434	18:51:40	1 Sep 92	R2451851.40B	N2451851.40	Bow	6	59	225	45	
462	435	18:55:40	1 Sep 92	R2451855.40B	N2451855.40	Bow	3	59	77	18	2, Long
463	436	18:56:13	1 Sep 92	R2451856.13S	N2451856.13	Side		59	438	65	Excellent
464	437	18:58:36	1 Sep 92	R2451858.36S	N2451858.36	Side		59	125	27	2
465	438	19:00:02	1 Sep 92	R2451900.02B	N2451900.02	Bow	3	59	102	20	
466	438	19:00:02	1 Sep 92	R2451900.02S	N2451900.02	Side		59	229	35	
467	439	19:00:55	1 Sep 92	R2451900.55B	N2451900.55	Bow	7	59	159	31	
468	440	19:01:39	1 Sep 92	R2451901.39B	N2451901.39	Bow	3	59	244	64	Long
469	441	19:04:32	1 Sep 92	R2451904.32B	N2451904.32	Bow	2	59	90	13	
470	441	19:04:32	1 Sep 92	R2451904.32S	N2451904.32	Side		59	69	14	
471	442	19:05:08	1 Sep 92	R2451905.08B	N2451905.08	Bow	6	59	28	14	2
472	442	19:05:08	1 Sep 92	R2451905.08S	N2451905.08	Side		59	97	16	
473	443	19:07:35	1 Sep 92	R2451907.35F	N2451907.35	Bottom		59	55	15	Excellent
474	443	19:07:35	1 Sep 92	R2451907.35T	N2451907.35	Transom		59	17	3	Noisy
475	444	19:08:59	1 Sep 92	R2451908.59B	N2451908.59	Bow	6	59	19	4	
476	444	19:08:59	1 Sep 92	R2451908.59S	N2451908.59	Side		59	71	16	
477	445	19:10:36	1 Sep 92	R2451910.36B	N2451910.36	Bow	2	59	76	14	Backing
478	445	19:10:36	1 Sep 92	R2451910.36S	N2451910.36	Side		59	38	5	Backing
479	446	19:11:05	1 Sep 92	R2451911.05S	N2451911.05	Side		59	171	29	Backing
480	446	19:11:05	1 Sep 92	R2451911.05T	N2451911.05	Transom		59	23	4	
481	447	19:11:38	1 Sep 92	R2451911.38S	N2451911.38	Side		59	101	15	
482	448	19:12:15	1 Sep 92	R2451912.15B	N2451912.15	Bow	7	59	139	48	
483	448	19:12:15	1 Sep 92	R2451912.15S	N2451912.15	Side		59	29	5	
484	449	19:14:32	1 Sep 92	R2451914.32S	N2451914.32	Side		59	144	32	
485	450	19:15:06	1 Sep 92	R2451915.06B	N2451915.06	Bow	7	59	70	19	2
486	450	19:15:06	1 Sep 92	R2451915.06S	N2451915.06	Side		59	40	7	
487	451	19:19:50	1 Sep 92	R2451919.50S	N2451919.50	Side		59	203	30	
488	451	19:19:50	1 Sep 92	R2451919.50T	N2451919.50	Transom		59	65	10	Spiky Event
489	452	19:34:35	1 Sep 92	R2451934.35S	N2451934.35	Side		59	174	31	
490	453	19:36:14	1 Sep 92	R2451936.14T	N2451936.14	Transom		59	93	15	
491	454	19:45:17	1 Sep 92	R2451945.17B	N2451945.17	Bow	6	59	72	21	3
492	454	19:45:17	1 Sep 92	R2451945.17S	N2451945.17	Side		59	173	35	
493	455	19:47:54	1 Sep 92	R2451947.54B	N2451947.54	Bow	3	59	112	27	Spiky Event
494	456	19:55:26	1 Sep 92	R2451955.26T	N2451955.26	Transom		59	53	13	Excellent
495	457	19:56:11	1 Sep 92	R2451956.11B	N2451956.11	Bow	7	59	142	27	
496	458	19:58:33	1 Sep 92	R2451958.33B	N2451958.33	Bow	6	59	50	12	
497	458	19:58:33	1 Sep 92	R2451958.33F	N2451958.33	Bottom		59	61	20	
498	458	19:58:33	1 Sep 92	R2451958.33S	N2451958.33	Side		59	24	4	
499	459	20:00:44	1 Sep 92	R2452000.44B	N2452000.44	Bow	7	59	276	49	2
500	460	20:17:04	1 Sep 92	R2452017.04T	N2452017.04	Transom		59	61	10	Simult. All Chans

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
501	461	20:22:50	1 Sep 92	R2452022.50B	N2452022.50	Bow	7	59	283	67	
502	462	20:26:05	1 Sep 92	R2452026.05B	N2452026.05	Bow	7	59	157	55	2
503	463	20:26:58	1 Sep 92	R2452026.58B	N2452026.58	Bow	7	59	301	95	
504	464	20:28:20	1 Sep 92	R2452028.20B	N2452028.20	Bow	7	59	316	75	
505	465	20:33:29	1 Sep 92	R2452033.29S	N2452033.29	Side		59	89	20	Slow Backing
506	466	20:35:17	1 Sep 92	R2452035.17B	N2452035.17	Bow	7	59	121	37	
507	467	20:40:27	1 Sep 92	R2452040.27B	N2452040.27	Bow	7	59	85	23	2
508	468	20:43:12	1 Sep 92	R2452043.12T	N2452043.12	Transom		59	57	9	Milling
509	469	20:49:00	1 Sep 92	R2452049.00S	N2452049.00	Side		59	82	11	
510	470	20:51:05	1 Sep 92	R2452051.05B	N2452051.05	Bow	4	59	53	18	
511	470	20:51:05	1 Sep 92	R2452051.05S	N2452051.05	Side		59	185	33	
512	471	20:51:34	1 Sep 92	R2452051.34B	N2452051.34	Bow	6	59	89	19	
513	471	20:51:34	1 Sep 92	R2452051.34S	N2452051.34	Side		59	133	23	2 Long
514	472	20:53:03	1 Sep 92	R2452053.03S	N2452053.03	Side		59	158	27	Long, Backing
515	473	21:14:25	1 Sep 92	R2452114.25B	N2452114.25	Bow	7	59	58	11	2
516	473	21:14:25	1 Sep 92	R2452114.25F	N2452114.25	Bottom		59	14	6	
517	474	21:15:34	1 Sep 92	R2452115.34B	N2452115.34	Bow	7	59	135	65	
518	482	21:20:27	1 Sep 92	R2452120.27B	N2452120.27	Bow	7	59	267	60	2
519	484	21:21:26	1 Sep 92	R2452121.26B	N2452121.26	Bow	6	59	207	38	
520	485	21:21:54	1 Sep 92	R2452121.54B	N2452121.54	Bow	4	59	90	16	
521	492	21:25:52	1 Sep 92	R2452125.52B	N2452125.52	Bow	4	59	46	7	
522	493	23:15:03	1 Sep 92	R2452315.03B	N2452315.03	Bow	7	59	186	83	2
523	494	23:24:33	1 Sep 92	R2452324.33B	N2452324.33	Bow	6	59	80	27	2
524	494	23:24:33	1 Sep 92	R2452324.33F	N2452324.33	Bottom		59	89	32	Excellent
525	495	23:34:55	1 Sep 92	R2452334.55B	N2452334.55	Bow	7	59	143	47	
526	496	23:36:27	1 Sep 92	R2452336.27B	N2452336.27	Bow	7	59	137	31	
527	497	0:00:35	2 Sep 92	R2460000.35B	N2460000.35	Bow	7	59	302	67	2
528	498	0:03:35	2 Sep 92	R2460003.35B	N2460003.35	Bow	3	59	79	23	2
529	498	0:03:35	2 Sep 92	R2460003.35S	N2460003.35	Side		59	79	17	2
530	499	0:35:14	2 Sep 92	R2460035.14S	N2460035.14	Side		59	81	20	Backing
531	500	0:36:30	2 Sep 92	R2460036.30B	N2460036.30	Bow	6	59	60	33	
532	500	0:36:30	2 Sep 92	R2460036.30S	N2460036.30	Side		59	153	42	
533	501	0:38:55	2 Sep 92	R2460038.55B	N2460038.55	Bow	5	59	151	39	
534	501	0:38:55	2 Sep 92	R2460038.55F	N2460038.55	Bottom		59	27	7	
535	501	0:38:55	2 Sep 92	R2460038.55S	N2460038.55	Side		59	60	16	
536	502	0:44:21	2 Sep 92	R2460044.21B	N2460044.21	Bow	7	59	50	12	
537	502	0:44:21	2 Sep 92	R2460044.21S	N2460044.21	Side		59	52	20	
538	503	0:49:53	2 Sep 92	R2460049.53S	N2460049.53	Side		59	679	123	Excellent
539	504	0:53:59	2 Sep 92	R2460053.59B	N2460053.59	Bow	5	59	72	53	Long
540	505	1:00:37	2 Sep 92	R2460100.37B	N2460100.37	Bow	6	59	66	23	
541	505	1:00:37	2 Sep 92	R2460100.37S	N2460100.37	Side		59	97	12	2
542	506	1:09:40	2 Sep 92	R2460109.40T	N2460109.40	Transom		59	55	9	Excellent, Milling
543	507	1:13:14	2 Sep 92	R2460113.14T	N2460113.14	Transom		59	33	6	Spike Removed
544	508	1:23:48	2 Sep 92	R2460123.48B	N2460123.48	Bow	7	59	274	48	
545	509	1:30:15	2 Sep 92	R2460130.15T	N2460130.15	Transom		59	86	14	Excellent
546	510	1:35:47	2 Sep 92	R2460135.47S	N2460135.47	Side		59	138	20	
547	511	1:40:14	2 Sep 92	R2460140.14T	N2460140.14	Transom		59	18	4	Noisy
548	512	1:45:58	2 Sep 92	R2460145.58T	N2460145.58	Transom		59	42	11	
549	513	1:48:13	2 Sep 92	R2460148.13B	N2460148.13	Bow	5	59	142	39	Long
550	514	1:54:22	2 Sep 92	R2460154.22T	N2460154.22	Transom		59	39	7	Spike Removed

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
551	515	1:56:57	2 Sep 92	R2460156.57B	N2460156.57	Bow	6	59	71	24	
552	515	1:56:57	2 Sep 92	R2460156.57S	N2460156.57	Side		59	65	10	
553	516	2:00:32	2 Sep 92	R2460200.32T	N2460200.32	Transom		59	74	13	Excellent
554	517	4:51:36	2 Sep 92	R2460451.36T	N2460451.36	Transom		59	49	10	Milling, Neg. Spike
555	518	4:52:15	2 Sep 92	R2460452.15S	N2460452.15	Side		59	87	14	
556	519	4:54:26	2 Sep 92	R2460454.26B	N2460454.26	Bow	7	59	266	73	
557	520	4:55:08	2 Sep 92	R2460455.08B	N2460455.08	Bow	2	59	24	4	
558	520	4:55:08	2 Sep 92	R2460455.08S	N2460455.08	Side		59	63	17	Long
559	522	4:56:59	2 Sep 92	R2460456.59B	N2460456.59	Bow	6	59	85	21	
560	522	4:56:59	2 Sep 92	R2460456.59S	N2460456.59	Side		59	37	7	
561	523	4:57:39	2 Sep 92	R2460457.39B	N2460457.39	Bow	5	59	41	12	
562	523	4:57:39	2 Sep 92	R2460457.39S	N2460457.39	Side		59	116	19	
563	524	5:00:33	2 Sep 92	R2460500.33B	N2460500.33	Bow	7	59	367	71	Excellent
564	525	5:02:31	2 Sep 92	R2460502.31T	N2460502.31	Transom		59	100	16	Fixed Neg. Spike
565	526	5:03:28	2 Sep 92	R2460503.28B	N2460503.28	Bow	7	59	314	104	
566	527	5:07:05	2 Sep 92	R2460507.05B	N2460507.05	Bow	5	59	38	12	
567	527	5:07:05	2 Sep 92	R2460507.05S	N2460507.05	Side		59	39	5	
568	528	5:09:22	2 Sep 92	R2460509.22B	N2460509.22	Bow	7	59	127	39	
569	528	5:09:22	2 Sep 92	R2460509.22S	N2460509.22	Side		59	103	18	2
570	529	5:20:29	2 Sep 92	R2460520.29T	N2460520.29	Transom		59	28	5	
571	530	5:23:56	2 Sep 92	R2460523.56B	N2460523.56	Bow	1	59	71	13	
572	530	5:23:56	2 Sep 92	R2460523.56S	N2460523.56	Side		59	55	10	Long
573	531	5:26:12	2 Sep 92	R2460526.12B	N2460526.12	Bow	6	59	261	48	
574	532	5:28:28	2 Sep 92	R2460528.28B	N2460528.28	Bow	5	59	60	54	Long
575	533	5:40:59	2 Sep 92	R2460540.59B	N2460540.59	Bow	4	59	82	31	
576	534	5:44:37	2 Sep 92	R2460544.37B	N2460544.37	Bow	7	59	121	23	
577	534	5:44:37	2 Sep 92	R2460544.37S	N2460544.37	Side		59	52	10	
578	535	5:45:12	2 Sep 92	R2460545.12S	N2460545.12	Side		59	45	8	
579	536	5:49:52	2 Sep 92	R2460549.52B	N2460549.52	Bow	7	59	180	36	
580	537	5:51:03	2 Sep 92	R2460551.03S	N2460551.03	Side		59	109	14	
581	538	5:55:14	2 Sep 92	R2460555.14B	N2460555.14	Bow	7	59	148	39	
582	539	5:56:10	2 Sep 92	R2460556.10B	N2460556.10	Bow	5	59	265	66	2
583	540	5:56:41	2 Sep 92	R2460556.41B	N2460556.41	Bow	4	59	119	18	
584	540	5:56:41	2 Sep 92	R2460556.41S	N2460556.41	Side		59	98	17	
585	541	5:57:13	2 Sep 92	R2460557.13S	N2460557.13	Side		59	69	11	
586	542	5:59:10	2 Sep 92	R2460559.10B	N2460559.10	Bow	7	59	109	27	
587	543	6:00:35	2 Sep 92	R2460600.35B	N2460600.35	Bow	7	59	153	48	
588	544	6:01:55	2 Sep 92	R2460601.55B	N2460601.55	Bow	7	59	165	34	
589	545	6:02:38	2 Sep 92	R2460602.38B	N2460602.38	Bow	7	59	122	47	3
590	546	6:03:16	2 Sep 92	R2460603.16B	N2460603.16	Bow	2	59	41	8	
591	546	6:03:16	2 Sep 92	R2460603.16S	N2460603.16	Side		59	44	6	
592	547	6:14:07	2 Sep 92	R2460614.07S	N2460614.07	Side		59	73	10	2
593	548	6:18:45	2 Sep 92	R2460618.45S	N2460618.45	Side		59	23	4	
594	549	6:19:29	2 Sep 92	R2460619.29S	N2460619.29	Side		59	116	19	
595	550	6:23:57	2 Sep 92	R2460623.57T	N2460623.57	Transom		59	122	30	3, Excellent, Milling
596	551	6:24:40	2 Sep 92	R2460624.40S	N2460624.40	Side		59	66	8	
597	552	6:25:16	2 Sep 92	R2460625.16B	N2460625.16	Bow	2	59	159	24	Long Evt on 1 Gage
598	553	6:26:00	2 Sep 92	R2460626.00S	N2460626.00	Side		59	26	4	Backing
599	554	6:27:18	2 Sep 92	R2460627.18S	N2460627.18	Side		59	66	10	
600	555	6:28:01	2 Sep 92	R2460628.01B	N2460628.01	Bow	7	59	77	23	

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
601	555	6:28:01	2 Sep 92	R2460628.01S	N2460628.01	Side		59	28	5	2
602	556	6:31:58	2 Sep 92	R2460631.58S	N2460631.58	Side		59	35	7	2
603	557	6:34:15	2 Sep 92	R2460634.15S	N2460634.15	Side		59	126	21	
604	557	6:34:15	2 Sep 92	R2460634.15T	N2460634.15	Transom		59	348	56	Excel., Backing, Mill.
605	558	6:36:20	2 Sep 92	R2460636.20T	N2460636.20	Transom		59	131	24	Excellent
606	563	6:45:16	2 Sep 92	R2460645.16B	N2460645.16	Bow	7	59	230	93	
607	564	6:45:48	2 Sep 92	R2460645.48S	N2460645.48	Side		59	172	28	Backing
608	565	6:49:40	2 Sep 92	R2460649.40B	N2460649.40	Bow	6	59	195	45	
609	566	6:54:50	2 Sep 92	R2460654.50S	N2460654.50	Side		59	75	12	Backing
610	567	6:56:14	2 Sep 92	R2460656.14B	N2460656.14	Bow	3	59	55	18	Long
611	569	10:29:04	2 Sep 92	R2461029.04S	N2461029.04	Side		59	265	50	
612	570	10:30:57	2 Sep 92	R2461030.57S	N2461030.57	Side		59	105	26	
613	571	10:32:27	2 Sep 92	R2461032.27B	N2461032.27	Bow	7	59	75	17	2
614	571	10:32:27	2 Sep 92	R2461032.27S	N2461032.27	Side		59	78	12	2
615	572	10:35:02	2 Sep 92	R2461035.02B	N2461035.02	Bow	6	59	224	64	
616	572	10:35:02	2 Sep 92	R2461035.02S	N2461035.02	Side		59	223	31	
617	573	10:37:18	2 Sep 92	R2461037.18B	N2461037.18	Bow	7	59	170	34	2
618	574	10:38:18	2 Sep 92	R2461038.18B	N2461038.18	Bow	3	59	254	46	Long
619	574	10:38:18	2 Sep 92	R2461038.18S	N2461038.18	Side		59	68	11	Long
620	575	10:41:18	2 Sep 92	R2461041.18B	N2461041.18	Bow	1	59	363	56	Spiky Event
621	575	10:41:18	2 Sep 92	R2461041.18S	N2461041.18	Side		59	143	18	2
622	576	10:43:38	2 Sep 92	R2461043.38S	N2461043.38	Side		59	77	10	Backing
623	577	10:44:14	2 Sep 92	R2461044.14S	N2461044.14	Side		59	184	32	Backing
624	578	10:44:54	2 Sep 92	R2461044.54S	N2461044.54	Side		59	290	83	2, Excellent
625	579	10:45:29	2 Sep 92	R2461045.29B	N2461045.29	Bow	7	59	59	20	
626	579	10:45:29	2 Sep 92	R2461045.29S	N2461045.29	Side		59	69	9	
627	580	10:46:44	2 Sep 92	R2461046.44B	N2461046.44	Bow	7	59	43	62	Long
628	580	10:46:44	2 Sep 92	R2461046.44S	N2461046.44	Side		59	143	19	Long
629	581	10:48:09	2 Sep 92	R2461048.09B	N2461048.09	Bow	5	59	63	11	
630	581	10:48:09	2 Sep 92	R2461048.09S	N2461048.09	Side		59	195	25	2
631	582	10:49:44	2 Sep 92	R2461049.44F	N2461049.44	Bottom		59	147	51	Excellent
632	583	10:58:18	2 Sep 92	R2461058.18B	N2461058.18	Bow	5	59	194	29	
633	584	10:59:16	2 Sep 92	R2461059.16B	N2461059.16	Bow	5	59	120	26	
634	585	11:01:06	2 Sep 92	R2461101.06B	N2461101.06	Bow	7	59	260	77	2
635	586	11:03:33	2 Sep 92	R2461103.33B	N2461103.33	Bow	7	59	141	87	3
636	587	11:04:35	2 Sep 92	R2461104.35B	N2461104.35	Bow	7	59	202	53	3
637	588	11:05:37	2 Sep 92	R2461105.37B	N2461105.37	Bow	5	59	33	12	
638	588	11:05:37	2 Sep 92	R2461105.37S	N2461105.37	Side		59	35	5	
639	589	11:07:14	2 Sep 92	R2461107.14B	N2461107.14	Bow	7	59	320	60	
640	590	11:08:01	2 Sep 92	R2461108.01S	N2461108.01	Side		59	33	5	2
641	591	11:10:34	2 Sep 92	R2461110.34S	N2461110.34	Side		59	45	10	
642	592	11:12:51	2 Sep 92	R2461112.51B	N2461112.51	Bow	6	59	380	104	2
643	593	11:14:42	2 Sep 92	R2461114.42B	N2461114.42	Bow	7	59	145	29	2
644	594	11:16:07	2 Sep 92	R2461116.07B	N2461116.07	Bow	7	59	117	40	
645	595	11:16:42	2 Sep 92	R2461116.42B	N2461116.42	Bow	7	59	280	168	3
646	596	11:18:19	2 Sep 92	R2461118.19B	N2461118.19	Bow	7	59	236	48	
647	596	11:18:19	2 Sep 92	R2461118.19F	N2461118.19	Bottom		59	23	12	
648	597	11:21:11	2 Sep 92	R2461121.11B	N2461121.11	Bow	7	59	153	32	
649	598	11:23:10	2 Sep 92	R2461123.10B	N2461123.10	Bow	7	59	213	59	Long
650	599	11:25:47	2 Sep 92	R2461125.47B	N2461125.47	Bow	7	59	170	78	Long

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
651	599	11:25:47	2 Sep 92	R2461125.47S	N2461125.47	Side		59	35	5	2
652	600	11:27:59	2 Sep 92	R2461127.59B	N2461127.59	Bow	7	59	100	22	2
653	612	20:39:48	2 Sep 92	R2462039.48S	N2462039.48	Side		59	229	29	
654	613	20:42:18	2 Sep 92	R2462042.18B	N2462042.18	Bow	5	59	206	40	
655	614	21:09:16	2 Sep 92	R2462109.16S	N2462109.16	Side		59	46	7	
656	615	22:13:58	2 Sep 92	R2462213.58B	N2462213.58	Bow	7	59	177	28	
657	616	22:24:42	2 Sep 92	R2462224.42B	N2462224.42	Bow	7	59	95	39	
658	617	22:28:42	2 Sep 92	R2462228.42B	N2462228.42	Bow	7	59	43	19	
659	617	22:28:42	2 Sep 92	R2462228.42S	N2462228.42	Side		59	154	23	
660	618	22:29:57	2 Sep 92	R2462229.57S	N2462229.57	Side		59	178	47	
661	619	22:35:39	2 Sep 92	R2462235.39B	N2462235.39	Bow	7	59	176	51	
662	620	22:38:05	2 Sep 92	R2462238.05B	N2462238.05	Bow	7	59	204	83	
663	621	22:49:43	2 Sep 92	R2462249.43B	N2462249.43	Bow	7	59	120	23	
664	622	22:54:55	2 Sep 92	R2462254.55B	N2462254.55	Bow	7	59	558	142	
665	623	22:58:04	2 Sep 92	R2462258.04B	N2462258.04	Bow	7	59	198	62	
666	624	23:09:48	2 Sep 92	R2462309.48B	N2462309.48	Bow	6	59	16	6	
667	624	23:09:48	2 Sep 92	R2462309.48S	N2462309.48	Side		59	83	17	
668	625	23:13:17	2 Sep 92	R2462313.17B	N2462313.17	Bow	7	59	103	30	
669	626	23:17:22	2 Sep 92	R2462317.22B	N2462317.22	Bow	3	59	20	5	
670	626	23:17:22	2 Sep 92	R2462317.22S	N2462317.22	Side		59	61	8	2
671	627	23:24:27	2 Sep 92	R2462324.27B	N2462324.27	Bow	3	59	45	11	
672	627	23:24:27	2 Sep 92	R2462324.27S	N2462324.27	Side		59	117	21	
673	628	23:31:27	2 Sep 92	R2462331.27B	N2462331.27	Bow	5	59	26	10	
674	628	23:31:27	2 Sep 92	R2462331.27S	N2462331.27	Side		59	90	13	
675	629	23:37:00	2 Sep 92	R2462337.00B	N2462337.00	Bow	7	59	399	89	
676	630	23:38:52	2 Sep 92	R2462338.52S	N2462338.52	Side		59	150	26	2
677	631	23:40:46	2 Sep 92	R2462340.46B	N2462340.46	Bow	6	59	207	39	
678	632	23:42:59	2 Sep 92	R2462342.59B	N2462342.59	Bow	7	59	112	38	2
679	633	23:47:43	2 Sep 92	R2462347.43S	N2462347.43	Side		59	150	19	
680	634	23:50:02	2 Sep 92	R2462350.02S	N2462350.02	Side		59	74	13	
681	635	23:51:03	2 Sep 92	R2462351.03B	N2462351.03	Bow	7	59	184	37	
682	636	23:55:12	2 Sep 92	R2462355.12B	N2462355.12	Bow	7	59	78	24	2
683	636	23:55:12	2 Sep 92	R2462355.12S	N2462355.12	Side		59	75	10	
684	637	23:59:07	2 Sep 92	R2462359.07B	N2462359.07	Bow	6	59	169	51	2
685	637	23:59:07	2 Sep 92	R2462359.07S	N2462359.07	Side		59	70	9	
686	638	0:01:00	3 Sep 92	R2470001.00B	N2470001.00	Bow	7	59	353	75	Excellent
687	639	0:03:17	3 Sep 92	R2470003.17B	N2470003.17	Bow	7	59	132	64	
688	640	0:04:34	3 Sep 92	R2470004.34B	N2470004.34	Bow	5	59	124	27	
689	641	0:05:24	3 Sep 92	R2470005.24B	N2470005.24	Bow	6	59	270	85	
690	642	0:06:38	3 Sep 92	R2470006.38B	N2470006.38	Bow	5	59	238	46	
691	643	0:08:30	3 Sep 92	R2470008.30B	N2470008.30	Bow	5	59	81	20	
692	643	0:08:30	3 Sep 92	R2470008.30F	N2470008.30	Bottom		59	14	7	
693	643	0:08:30	3 Sep 92	R2470008.30S	N2470008.30	Side		59	88	19	
694	644	0:10:13	3 Sep 92	R2470010.13B	N2470010.13	Bow	7	59	183	49	
695	645	0:11:19	3 Sep 92	R2470011.19B	N2470011.19	Bow	7	59	371	66	
696	645	0:11:19	3 Sep 92	R2470011.19F	N2470011.19	Bottom		59	15	10	Neg. Strains
697	646	0:13:55	3 Sep 92	R2470013.55B	N2470013.55	Bow	7	59	127	25	
698	647	0:14:41	3 Sep 92	R2470014.41B	N2470014.41	Bow	6	59	260	106	
699	648	0:15:34	3 Sep 92	R2470015.34B	N2470015.34	Bow	5	59	63	15	
700	648	0:15:34	3 Sep 92	R2470015.34S	N2470015.34	Side		59	53	8	2

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement Summary of Reduced Impact Events by Day (Continued)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press. (psi)	Max Force (LT)	Comments
701	649	0:17:12	3 Sep 92	R2470017.12B	N2470017.12	Bow	3	59	151	44	
702	650	0:17:59	3 Sep 92	R2470017.59B	N2470017.59	Bow	2	59	234	50	
703	651	0:18:47	3 Sep 92	R2470018.47B	N2470018.47	Bow	7	59	255	53	3
704	652	0:22:09	3 Sep 92	R2470022.09B	N2470022.09	Bow	6	59	85	16	2
705	653	0:22:56	3 Sep 92	R2470022.56B	N2470022.56	Bow	7	59	388	74	
706	654	0:26:17	3 Sep 92	R2470026.17B	N2470026.17	Bow	7	59	96	34	2
707	655	0:27:30	3 Sep 92	R2470027.30B	N2470027.30	Bow	5	59	166	47	
708	656	0:29:13	3 Sep 92	R2470029.13S	N2470029.13	Side		59	72	11	
709	657	0:31:18	3 Sep 92	R2470031.18S	N2470031.18	Side		59	125	25	
710	658	1:08:06	3 Sep 92	R2470108.06T	N2470108.06	Transom		59	54	10	Long Excel
711	659	1:12:24	3 Sep 92	R2470112.24S	N2470112.24	Side		59	157	28	
712	660	1:13:44	3 Sep 92	R2470113.44S	N2470113.44	Side		59	105	14	
713	661	1:15:12	3 Sep 92	R2470115.12B	N2470115.12	Bow	3	59	91	24	2
714	662	1:17:50	3 Sep 92	R2470117.50S	N2470117.50	Side		59	156	20	
715	663	1:19:02	3 Sep 92	R2470119.02B	N2470119.02	Bow	5	59	96	31	2
716	664	1:19:49	3 Sep 92	R2470119.49B	N2470119.49	Bow	7	59	164	48	
717	665	1:20:41	3 Sep 92	R2470120.41B	N2470120.41	Bow	7	59	169	61	
718	665	1:20:41	3 Sep 92	R2470120.41S	N2470120.41	Side		59	34	7	
719	666	1:21:17	3 Sep 92	R2470121.17B	N2470121.17	Bow	7	59	237	45	
720	667	1:27:02	3 Sep 92	R2470127.02B	N2470127.02	Bow	7	59	93	76	
721	667	1:27:02	3 Sep 92	R2470127.02F	N2470127.02	Bottom		59	20	6	
722	668	1:29:23	3 Sep 92	R2470129.23B	N2470129.23	Bow	7	59	139	45	
723	669	11:31:02	6 Sep 92	R2501131.02B	N2501131.02	Bow	4	59	27	5	
724	669	11:31:02	6 Sep 92	R2501131.02S	N2501131.02	Side		59	72	19	2
725	670	14:04:41	6 Sep 92	R2501404.41S	N2501404.41	Side		59	127	23	
726	671	14:05:18	6 Sep 92	R2501405.18S	N2501405.18	Side		59	89	15	
727	672	14:10:54	6 Sep 92	R2501410.54S	N2501410.54	Side		59	169	28	2
728	673	14:11:47	6 Sep 92	R2501411.47B	N2501411.47	Bow	1	59	43	7	
729	673	14:11:47	6 Sep 92	R2501411.47S	N2501411.47	Side		59	77	19	
730	675	18:16:23	6 Sep 92	R2501816.23B	N2501816.23	Bow	7	59	311	77	3
731	676	18:57:43	6 Sep 92	R2501857.43B	N2501857.43	Bow	2	59	107	23	
732	677	18:59:51	6 Sep 92	R2501859.51B	N2501859.51	Bow	7	59	96	33	2
733	678	20:23:44	6 Sep 92	R2502023.44S	N2502023.44	Side		59	52	7	
734	679	20:25:16	6 Sep 92	R2502025.16S	N2502025.16	Side		59	113	25	
735	680	0:34:13	7 Sep 92	R2510034.13S	N2510034.13	Side		59	108	17	Backing
736	681	0:40:42	7 Sep 92	R2510040.42B	N2510040.42	Bow	6	59	124	31	
737	681	0:40:42	7 Sep 92	R2510040.42S	N2510040.42	Side		59	83	13	
738	682	0:41:48	7 Sep 92	R2510041.48S	N2510041.48	Side		59	76	16	
739	683	0:42:21	7 Sep 92	R2510042.21B	N2510042.21	Bow	5	59	43	17	
740	683	0:42:21	7 Sep 92	R2510042.21S	N2510042.21	Side		59	105	29	
741	684	0:43:37	7 Sep 92	R2510043.37B	N2510043.37	Bow	4	59	122	43	3
742	684	0:43:37	7 Sep 92	R2510043.37S	N2510043.37	Side		59	246	44	2
743	685	0:44:16	7 Sep 92	R2510044.16B	N2510044.16	Bow	7	59	330	88	
744	685	0:44:16	7 Sep 92	R2510044.16S	N2510044.16	Side		59	167	35	
745	686	0:48:33	7 Sep 92	R2510048.33B	N2510048.33	Bow	4	59	149	22	
746	686	0:48:33	7 Sep 92	R2510048.33S	N2510048.33	Side		59	54	9	
747	687	1:54:43	7 Sep 92	R2510154.43B	N2510154.43	Bow	7	59	83	35	
748	688	13:43:31	7 Sep 92	R2511343.31B	N2511343.31	Bow	5	59	99	30	2
749	689	20:08:59	7 Sep 92	R2512008.59B	N2512008.59	Bow	3	59	151	27	
750	690	20:13:29	7 Sep 92	R2512013.29S	N2512013.29	Side		59	55	9	Backing

Table D-2. *Nathaniel B. Palmer* Ice Loads Measurement
Summary of Reduced Impact Events by Day (Concluded)

Event No.	Record No.	Time GMT	Date	Reduced Data File Name	Raw Data File Name	Panel Location	No. Bow Frames	Chans Active	Max Press.	Max Force	Comments
									(psi)	(LT)	
751	691	14:06:05	8 Sep 92	R2521406.05B	N2521406.05	Bow	5	59	87	36	
752	692	16:26:13	8 Sep 92	R2521626.13B	N2521626.13	Bow	4	59	47	17	2
753	693	16:33:57	8 Sep 92	R2521633.57B	N2521633.57	Bow	6	59	66	50	3
754	693	16:33:57	8 Sep 92	R2521633.57T	N2521633.57	Transom		59	19	3	
755	694	16:34:40	8 Sep 92	R2521634.40B	N2521634.40	Bow	7	59	65	49	3
756	695	16:35:33	8 Sep 92	R2521635.33B	N2521635.33	Bow	7	59	80	42	3
757	696	16:36:05	8 Sep 92	R2521636.05B	N2521636.05	Bow	7	59	106	42	3
758	696	16:36:05	8 Sep 92	R2521636.05S	N2521636.05	Side		59	128	23	3
759	697	16:36:39	8 Sep 92	R2521636.39B	N2521636.39	Bow	4	59	92	27	2
760	697	16:36:39	8 Sep 92	R2521636.39S	N2521636.39	Side		59	228	46	Long
761	698	16:37:10	8 Sep 92	R2521637.10B	N2521637.10	Bow	5	59	107	27	
762	698	16:37:10	8 Sep 92	R2521637.10S	N2521637.10	Side		59	174	33	
763	699	16:37:45	8 Sep 92	R2521637.45B	N2521637.45	Bow	7	59	170	44	3
764	699	16:37:45	8 Sep 92	R2521637.45S	N2521637.45	Side		59	69	17	
765	700	16:38:16	8 Sep 92	R2521638.16B	N2521638.16	Bow	4	59	92	22	
766	700	16:38:16	8 Sep 92	R2521638.16S	N2521638.16	Side		59	147	36	
767	701	16:38:49	8 Sep 92	R2521638.49B	N2521638.49	Bow	3	59	169	40	
768	701	16:38:49	8 Sep 92	R2521638.49S	N2521638.49	Side		59	247	63	2
769	702	16:40:22	8 Sep 92	R2521640.22B	N2521640.22	Bow	4	59	80	24	
770	702	16:40:22	8 Sep 92	R2521640.22S	N2521640.22	Side		59	120	24	
771	703	16:40:48	8 Sep 92	R2521640.48B	N2521640.48	Bow	5	59	91	31	
772	703	16:40:48	8 Sep 92	R2521640.48S	N2521640.48	Side		59	98	25	
773	704	18:40:31	8 Sep 92	R2521840.31S	N2521840.31	Side		59	217	39	
774	705	18:41:13	8 Sep 92	R2521841.13B	N2521841.13	Bow	2	59	72	18	
775	705	18:41:13	8 Sep 92	R2521841.13S	N2521841.13	Side		59	137	25	
776	706	18:41:54	8 Sep 92	R2521841.54B	N2521841.54	Bow	2	59	58	10	
777	706	18:41:54	8 Sep 92	R2521841.54S	N2521841.54	Side		59	115	24	
778	707	18:44:01	8 Sep 92	R2521844.01B	N2521844.01	Bow	6	59	71	14	
779	708	18:44:35	8 Sep 92	R2521844.35B	N2521844.35	Bow	3	59	55	15	
780	708	18:44:35	8 Sep 92	R2521844.35S	N2521844.35	Side		59	125	25	
781	709	18:45:41	8 Sep 92	R2521845.41B	N2521845.41	Bow	2	59	30	10	
782	709	18:45:41	8 Sep 92	R2521845.41S	N2521845.41	Side		59	97	15	2
783	710	18:46:19	8 Sep 92	R2521846.19B	N2521846.19	Bow	3	59	81	35	2
784	711	18:47:24	8 Sep 92	R2521847.24B	N2521847.24	Bow	4	59	103	25	3
785	712	19:24:48	8 Sep 92	R2521924.48B	N2521924.48	Bow	3	59	63	17	
786	712	19:24:48	8 Sep 92	R2521924.48S	N2521924.48	Side		59	71	12	2
787	713	19:37:05	8 Sep 92	R2521937.05B	N2521937.05	Bow	4	59	47	8	
788	713	19:37:05	8 Sep 92	R2521937.05S	N2521937.05	Side		59	46	12	2
789	714	19:39:05	8 Sep 92	R2521939.05B	N2521939.05	Bow	1	59	26	7	
790	714	19:39:05	8 Sep 92	R2521939.05S	N2521939.05	Side		59	100	17	
791	715	20:18:05	8 Sep 92	R2522018.05B	N2522018.05	Bow	3	59	101	23	
792	716	13:54:43	9 Sep 92	R2531354.43S	N2531354.43	Side		59	252	45	Long
793	717	14:15:34	9 Sep 92	R2531415.34B	N2531415.34	Bow	5	59	80	34	3
794	718	14:16:57	9 Sep 92	R2531416.57B	N2531416.57	Bow	6	59	88	39	3
795	719	14:18:19	9 Sep 92	R2531418.19B	N2531418.19	Bow	7	59	66	60	2
796	720	15:34:10	9 Sep 92	R2531534.10B	N2531534.10	Bow	5	59	83	19	2

APPENDIX E

ICE IMPACT EVENT DATA CORRELATED WITH SHIP SPEED AND ICE CONDITIONS

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	New and Grey Ice (0 - .5 ft) (Tenths)	Grey-White (.5 - 1 ft) (Tenths)	First Yr Thin Ice (1 - 2 ft) (Tenths)	First Yr Med. Ice (2 - 4 ft) (Tenths)	First Yr Thick Ice (4 - 6 ft) (Tenths)	Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness Avg. (ft)	Level Ice Thickness Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size Avg. (ft)	Floe Size Max (ft)
1	Bow	28 Aug 92	15:57:34	129	73	23	22	6.8	7.8	10			4	5	1				3	S	50	130
2	Bow	28 Aug 92	16:12:02	158	92	29	23	7.8		10			3	6	1				3.5	S	50	120
3	Trans	28 Aug 92	16:12:02	37	37	6	6	7.8		10			3	6	1				3.5	S	50	120
4	Bow	28 Aug 92	16:14:56	568	533	109	94	4.7		10			3	6	1				3.5	S	50	120
5	Bow	28 Aug 92	16:22:45	735	705	178	109	5.4		10			3	6	1				3.5	S	50	120
6	Side	28 Aug 92	16:28:26	154	134	51	32	3.8		10			3	6	1				3.5	S	50	120
7	Bow	28 Aug 92	16:30:22	176	100	48	30	3.8		10			3	6	1				3.5	S	50	120
8	Bow	28 Aug 92	16:39:27	490	461	84	73	5.2		10			3	6	1				3.5	S	50	120
9	Bow	28 Aug 92	16:57:22	361	361	54	54	5.6		10			3	6	1				3.5	S	50	120
10	Bow	28 Aug 92	17:07:50	435	435	65	65	4.9	2.8	10			3	6	1				3	S	50	120
11	Bow	28 Aug 92	21:11:46	289	289	43	43	3.6	1	8.5			2.5	5.5	0.5				3	N	50	150
12	Bow	28 Aug 92	23:54:01	323	238	62	48	1.9	2.2	9				6	2	1	3		3	S	50	250
13	Bow	29 Aug 92	0:17:39	269	157	47	44	1.8	1.8	9				2	5	2	3	6	3	N	50	160
14	Bow	29 Aug 92	0:24:46	288	165	74	43	2.9	1.8	9				2	5	2	3	6	3	N	50	160
15	Bow	29 Aug 92	1:27:16	191	136	47	40	0.0	2.2	9				2	4	3	4	6	3	N	180	350
16	Bow	29 Aug 92	1:50:55	213	131	44	34	2.8	2.2	9				2	4	3	4	6	3	N	180	350
17	Bow	29 Aug 92	2:06:33	233	213	52	43	0.0	1.4	9			3	5	1		2	4	1	N	50	100
18	Bow	29 Aug 92	2:24:35	240	171	43	36	5.4	1.4	9			3	5	1		2	4	1	N	50	100
19	Bow	29 Aug 92	2:32:27	245	172	55	36	1.8	1.4	9			3	5	1		2	4	1	N	50	100
20	Bow	29 Aug 92	2:41:42	454	411	125	76	4.5	1.4	9			3	5	1		2	4	1	N	50	100
21	Bow	29 Aug 92	13:22:14	164	149	51	41	4.5	3	8	2		5			1				N	25	100
22	Bow	29 Aug 92	13:43:37	130	114	61	24	2.8	3	8	2		5			1				N	25	100
23	Bow	29 Aug 92	13:44:36	436	370	163	74	7.9	3	8	2		5			1				N	25	100
24	Bow	29 Aug 92	13:49:02	239	171	61	51	4.1	3	8	2		5			1				N	25	100
25	Bow	29 Aug 92	14:20:41	359	321	91	60	2.7	Stopped	7	2		4			1				N	25	100
26	Bow	29 Aug 92	14:23:20	324	209	168	50	5.9	Stopped	7	2		4			1				N	25	100
27	Bow	29 Aug 92	14:29:00	66	36	15	10	5.3	Stopped	7	2		4			1				N	25	100
28	Bow	29 Aug 92	16:23:45	201	201	52	35	2.0														
29	Bow	29 Aug 92	16:40:28	139	131	31	23	1.6														
30	Bow	30 Aug 92	2:20:54	210	184	43	31	2.3	1.6	10				10					1.5	E	25	300
31	Bow	30 Aug 92	2:31:36	201	201	52	34	3.3	1.6	10				10					1.5	E	25	300
32	Bow	30 Aug 92	2:41:24	198	169	55	37	5.6	1.6	10				10					1.5	E	25	300
33	Bow	30 Aug 92	2:44:00	144	123	28	21	5.0	1.6	10				10					1.5	E	25	300
34	Bow	30 Aug 92	2:48:24	169	86	34	25	3.1	1.6	10				10					1.5	E	25	300
35	Bow	30 Aug 92	2:49:48	207	192	43	37	3.9	1.6	10				10					1.5	E	25	300
36	Bow	30 Aug 92	3:29:44	252	229	46	37	5.3	2.6	9	2	1	1	5	1				1-1.5		15	200
37	Bow	30 Aug 92	4:22:07	578	336	93	86	1.8	3	9.50			1	8	1				1-1.5		50	200
38	Bow	30 Aug 92	4:37:43	158	88	47	26	1.1	3	9.50			1	8	1				1-1.5		50	200
39	Side	30 Aug 92	4:41:13	219	184	64	54	4.6	3	9.50			1	8	1				1-1.5		50	200
40	Bow	30 Aug 92	5:05:18	179	163	32	27	8.9	2	9.50			1	8	1				1-1.5		50	100
41	Side	30 Aug 92	5:05:18	27	16	4	3	8.9	2	9.50			1	8	1				1-1.5		50	100
42	Side	30 Aug 92	5:22:24	87	87	13	13	3.4	2	9.50			1	8	1				1-1.5		50	100
43	Side	30 Aug 92	6:09:12	79	38	13	12	1.3	2.5	10			1	8	1				1-1.5		50	200
44	Side	30 Aug 92	6:26:07	146	74	22	22	3.6	2.5	10			1	8	1				1-1.5		50	200
45	Bow	30 Aug 92	6:35:33	203	127	34	30	6.8	2.5	10			1	8	1				1-1.5		50	200

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration												
										Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice	Level Ice Thickness			Ice Pressure	Floe Size	
Event No.	Hull Panel	Date	Time (GMT)	Time of Pk Pres (psi)	Time of Pk Force (psi)	Max Local Load (LT)	Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Total (Tenths)	(0 - .5 ft) (Tenths)	(.5 - 1 ft) (Tenths)	(1 - 2 ft) (Tenths)	(2 - 4 ft) (Tenths)	(4 - 6 ft) (Tenths)	(2nd Year & Multi-Year Ice) (Tenths)	Avg. (ft)	Max (ft)	Snow Depth (ft)	(None, Some, Extreme)	Avg. (ft)	Max (ft)
46	Bow	30 Aug 92	6:52:43	182	102	59	28	0.7	2.5	10			1	8	1				1-1.5		50	200
47	Bow	30 Aug 92	6:59:04	105	62	27	16	—	2.5	10			1	8	1				1-1.5		50	200
48	Bow	30 Aug 92	7:00:38	255	174	61	40	2.9	2	9			1	9					1.5		100	300
49	Bow	30 Aug 92	7:04:10	277	239	62	52	1.6	2	9			1	9					1.5		100	300
50	Side	30 Aug 92	7:08:33	144	101	33	19	5.4	2	9			1	9					1.5		100	300
51	Bow	30 Aug 92	7:15:53	118	95	39	27	5.4	2	9			1	9					1.5		100	300
52	Bow	30 Aug 92	7:16:38	195	190	44	29	6.0	2	9			1	9					1.5		100	300
53	Side	30 Aug 92	7:40:14	88	38	12	11	0.8	2	9			1	9					1.5		100	300
54	Bow	30 Aug 92	7:43:08	213	193	108	33	4.3	2	9			1	9					1.5		100	300
55	Bow	30 Aug 92	8:01:30	188	119	32	28	1.5	2.5	9.5			1	9					1.5	S	100	300
56	Bow	30 Aug 92	8:06:31	121	121	29	18	—	2.5	9.5			1	9					1.5	S	100	300
57	Bow	30 Aug 92	8:10:33	233	106	46	36	4.3	2.5	9.5			1	9					1.5	S	100	300
58	Bow	30 Aug 92	8:22:00	419	293	89	65	—	2.5	9.5			1	9					1.5	S	100	300
59	Bow	30 Aug 92	8:24:12	329	287	66	53	2.3	2.5	9.5			1	9					1.5	S	100	300
60	Bow	30 Aug 92	8:31:04	425	425	86	63	7.6	2.5	9.5			1	9					1.5	S	100	300
61	Bow	30 Aug 92	8:50:07	152	126	35	23	4.4	2.5	9.5			1	9					1.5	S	100	300
62	Bow	30 Aug 92	8:50:40	295	219	87	47	3.2	2.5	9.5			1	9					1.5	S	100	300
63	Bow	30 Aug 92	8:53:02	162	162	53	29	5.6	2.5	9.5			1	9					1.5	S	100	300
64	Bow	30 Aug 92	8:58:08	217	195	51	42	1.6	2.5	9.5			1	9					1.5	S	100	300
65	Bow	30 Aug 92	8:58:48	459	223	97	72	3.6	2.5	9.5			1	9					1.5	S	100	300
66	Bow	30 Aug 92	9:01:54	65	59	17	15	3.5	3	9		1	1	7					1.5	S	50	300
67	Bow	30 Aug 92	9:24:03	97	97	23	14	4.0	3	9		1	1	7					1.5	S	50	300
68	Bow	30 Aug 92	9:26:50	158	158	28	23	3.7	3	9		1	1	7					1.5	S	50	300
69	Bow	30 Aug 92	9:32:29	69	69	18	12	4.6	3	9		1	1	7					1.5	S	50	300
70	Bow	30 Aug 92	9:37:34	169	121	37	25	4.0	3	9		1	1	7					1.5	S	50	300
71	Bow	30 Aug 92	9:42:17	168	134	31	25	2.4	3	9		1	1	7					1.5	S	50	300
72	Bow	30 Aug 92	9:57:16	130	79	36	24	3.2	3	9		1	1	7					1.5	S	50	200
73	Bow	30 Aug 92	10:27:37	141	104	42	33	3.2	3	9		2	1	6					1.5	S	50	200
74	Bow	30 Aug 92	10:34:14	86	85	29	24	5.5	3	9		2	1	6					1.5	S	50	200
75	Bow	30 Aug 92	10:39:55	147	144	29	22	2.7	3	9		2	1	6					1.5	S	50	200
76	Bow	30 Aug 92	10:48:46	121	86	49	18	3.6	3	9		2	1	6					1.5	S	50	200
77	Bow	30 Aug 92	10:50:09	227	204	77	34	4.7	3	9		2	1	6					1.5	S	50	200
78	Bow	30 Aug 92	10:56:55	98	87	28	18	3.7	3	9		2	1	6					1.5	S	50	200
79	Bow	30 Aug 92	10:58:54	232	232	73	34	5.3	3	9		2	1	6					1.5	S	50	200
80	Bow	30 Aug 92	11:05:05	123	85	30	18	6.6	5	3		1	2						1		5	25
81	Bow	30 Aug 92	12:55:32	75	72	21	11	10.4	7	3		1	1	1			3	5	1	N	5	15
82	Bow	30 Aug 92	13:56:52	390	363	110	96	0.5	7	3		1	1	1			3	5	1	N	5	15
83	Bow	30 Aug 92	13:57:22	314	313	74	52	0.8	7	3		1	1	1			3	5	1	N	5	15
84	Bow	30 Aug 92	13:57:49	283	282	68	47	0.0	7	3		1	1	1			3	5	1	N	5	15
85	Bow	30 Aug 92	13:58:18	254	254	61	42	1.0	7	3		1	1	1			3	5	1	N	5	15
86	Bow	30 Aug 92	13:58:48	249	249	62	42	0.8	7	3		1	1	1			3	5	1	N	5	15
87	Bow	30 Aug 92	13:59:18	232	229	56	39	0.2	7	3		1	1	1			3	5	1	N	5	15
88	Bow	30 Aug 92	13:59:47	229	222	56	38	1.0	7	3		1	1	1			3	5	1	N	5	15
89	Bow	30 Aug 92	14:00:19	226	225	59	40	0.5	2	8		2		4	2		3	6	1	S	75	500
90	Bow	30 Aug 92	14:00:52	223	220	52	36	0.2	2	8		2		4	2		3	6	1	S	75	500

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
91	Bow	30 Aug 92	14:01:18	215	211	51	35	0.0	2	8		2		4	2		3	6	1	S	75	500
92	Bow	30 Aug 92	14:01:46	213	212	50	35	0.2	2	8		2		4	2		3	6	1	S	75	500
93	Bow	30 Aug 92	14:02:14	224	219	55	45	0.5	2	8		2		4	2		3	6	1	S	75	500
94	Bow	30 Aug 92	14:05:31	106	98	24	20	2.3	2	8		2		4	2		3	6	1	S	75	500
95	Bow	30 Aug 92	14:10:05	287	287	86	43	5.3	2	8		2		4	2		3	6	1	S	75	500
96	Bow	30 Aug 92	14:10:38	77	45	28	14	8.6	2	8		2		4	2		3	6	1	S	75	500
97	Bow	30 Aug 92	14:12:15	150	114	26	22	4.9	2	8		2		4	2		3	6	1	S	75	500
98	Bow	30 Aug 92	14:13:52	504	336	133	103	5.0	2	8		2		4	2		3	6	1	S	75	500
99	Bow	30 Aug 92	14:31:25	266	187	76	40	7.4	2	8		2		4	2		3	6	1	S	75	500
100	Bow	30 Aug 92	14:32:00	176	176	32	26	2.1	2	8		2		4	2		3	6	1	S	75	500
101	Bow	30 Aug 92	14:48:16	556	420	108	89	2.1	2	8		2		4	2		3	6	1	S	75	500
102	Bow	30 Aug 92	14:50:13	154	120	34	23	3.8	2	8		2		4	2		3	6	1	S	75	500
103	Bow	30 Aug 92	14:55:17	184	121	52	27	3.6	2	8		2		4	2		3	6	1	S	75	500
104	Bow	30 Aug 92	15:10:09	227	173	53	34	7.4		7			1	5	1		4	5	1.5	N	150	600
105	Bow	30 Aug 92	15:19:10	75	75	11	11	4.2		7			1	5	1		4	5	1.5	N	150	600
106	Bow	30 Aug 92	15:25:53	131	103	27	21	2.3		7			1	5	1		4	5	1.5	N	150	600
107	Bow	30 Aug 92	15:35:16	123	58	35	20	7.2		7			1	5	1		4	5	1.5	N	150	600
108	Bow	30 Aug 92	16:15:49	180	180	49	39	—		7			1	5	1		4	5	1.5	N	100	800
109	Bow	30 Aug 92	16:24:07	78	78	19	13	8.0		7			1	5	1		4	5	1.5	N	100	800
110	Bow	30 Aug 92	16:29:58	162	118	54	31	—		7			1	5	1		4	5	1.5	N	100	800
111	Bow	30 Aug 92	16:53:10	207	183	58	35	Gap		7			1	5	1		4	5	1.5	N	100	800
112	Bow	30 Aug 92	16:53:53	109	96	39	16	6.1		7			1	5	1		4	5	1.5	N	100	800
113	Bow	30 Aug 92	16:57:14	192	156	49	29	2.0		7			1	5	1		4	5	1.5	N	100	800
114	Bow	30 Aug 92	16:57:45	65	63	20	12	1.5		7			1	5	1		4	5	1.5	N	100	800
115	Bow	30 Aug 92	17:25:47	83	45	18	12	Gap	4	9				7	2		4	5	1.5	N	100	800
116	Bow	30 Aug 92	17:28:50	148	148	43	27	2.8	4	9				7	2		4	5	1.5	N	100	800
117	Bow	30 Aug 92	17:31:47	162	162	24	24	5.0	4	9				7	2		4	5	1.5	N	100	800
118	Bow	30 Aug 92	17:34:33	116	106	21	17	4.4	4	9				7	2		4	5	1.5	N	100	800
119	Bow	30 Aug 92	17:44:01	140	140	45	21	3.9	4	9				7	2		4	5	1.5	N	100	800
120	Bow	30 Aug 92	17:52:15	291	291	51	43	4.1	4	9				7	2		4	5	1.5	N	100	800
121	Bow	30 Aug 92	17:53:16	348	348	66	54	2.6	4	9				7	2		4	5	1.5	N	100	800
122	Bow	30 Aug 92	17:53:52	128	108	31	19	3.9	4	9				7	2		4	5	1.5	N	100	800
123	Bow	30 Aug 92	17:54:24	111	111	21	16	0.6	4	9				7	2		4	5	1.5	N	100	800
124	Bow	30 Aug 92	17:56:05	123	122	20	19	5.7	4	9				7	2		4	5	1.5	N	100	800
125	Bow	30 Aug 92	17:58:53	155	155	39	25	4.8	4	9				7	2		4	5	1.5	N	100	800
126	Bow	30 Aug 92	18:09:34	66	59	25	15	7.9														
127	Bow	30 Aug 92	18:12:22	208	155	47	31	6.9														
128	Bow	30 Aug 92	18:13:12	55	44	24	14	—														
129	Bow	30 Aug 92	18:15:05	106	96	27	17	—														
130	Bow	30 Aug 92	18:21:01	458	320	125	71	5.2														
131	Bow	30 Aug 92	18:32:27	195	111	37	29	2.9														
132	Bow	30 Aug 92	18:35:06	90	90	13	13	4.1														
133	Bow	30 Aug 92	18:35:52	111	105	34	18	4.0														
134	Bow	30 Aug 92	18:38:50	120	71	26	18	3.5														
135	Bow	30 Aug 92	18:44:32	90	78	28	15	5.0														

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration												
										Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice	Level Ice Thickness			Ice Pressure	Floe Size	
Event No.	Hull Panel	Date	Time	Time of Pk Pres	Time of Pk Force	Max Local Load	Max Frame Load	Speed from GPS	Avg. Ship SOA	Total	(0 - .5 ft)	(.5 - 1 ft)	(1 - 2 ft)	(2 - 4 ft)	(4 - 6 ft)	(2nd Year & Multi-Year Ice)	Avg.	Max	Snow Depth	(None, Some, Extreme)	Avg.	Max
			(GMT)	(psi)	(psi)	(LT)	(LT)	(kt)	(kt)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(ft)	(ft)	(ft)		(ft)	(ft)
136	Bow	30 Aug 92	18:56:34	138	103	42	21	2.8														
137	Bow	30 Aug 92	19:02:29	222	70	59	52	4.9	0.2	9					7	2	4	7	2	N	100	700
138	Bow	30 Aug 92	19:06:52	588	472	123	93	3.6	0.2	9					7	2	4	7	2	N	100	700
139	Bow	30 Aug 92	19:07:40	130	130	22	22	0.5	0.2	9					7	2	4	7	2	N	100	700
140	Bow	30 Aug 92	19:10:10	174	166	41	29	5.2	0.2	9					7	2	4	7	2	N	100	700
141	Bow	30 Aug 92	19:13:34	196	196	29	29	4.7	0.2	9					7	2	4	7	2	N	100	700
142	Bow	30 Aug 92	19:21:34	60	60	13	13	3.7	0.2	9					7	2	4	7	2	N	100	700
143	Bow	30 Aug 92	19:37:41	105	92	17	16	6.9	0.2	9					7	2	4	7	2	N	100	700
144	Bow	30 Aug 92	19:48:18	114	102	43	20	3.8	0.2	9					7	2	4	7	2	N	100	700
145	Bow	30 Aug 92	19:49:49	304	201	86	67	4.0	0.2	9					7	2	4	7	2	N	100	700
146	Bow	30 Aug 92	19:57:00	242	177	49	39	2.9	0.2	9					7	2	4	7	2	N	100	700
147	Bow	30 Aug 92	19:58:41	126	68	19	19	—	0.2	9					7	2	4	7	2	N	100	700
148	Bow	30 Aug 92	20:18:11	97	97	14	14	2.8	0.1	9					7	2	4	7	2	N	100	600
149	Bow	30 Aug 92	20:49:22	147	142	36	25	8.8	0.1	9					7	2	4	7	2	N	100	600
150	Bow	30 Aug 92	21:05:36	70	70	14	10	6.6	0.1	10		1			7	2	5	8	3	S	100	400
151	Bow	30 Aug 92	21:14:23	67	63	19	10	4.6	0.1	10		1			7	2	5	8	3	S	100	400
152	Bow	30 Aug 92	21:17:16	178	144	36	26	4.4	0.1	10		1			7	2	5	8	3	S	100	400
153	Bow	30 Aug 92	21:26:53	62	54	14	10	2.2	0.1	10		1			7	2	5	8	3	S	100	400
154	Bow	30 Aug 92	21:33:52	84	84	13	12	9.0	0.1	10		1			7	2	5	8	3	S	100	400
155	Bow	30 Aug 92	21:36:31	403	375	62	60	6.5	0.1	10		1			7	2	5	8	3	S	100	400
156	Bow	30 Aug 92	21:38:35	142	134	31	22	9.3	0.1	10		1			7	2	5	8	3	S	100	400
157	Bow	30 Aug 92	22:40:10	262	222	44	44	2.1	1	10		1			7	2	4	7	3	S	100	500
158	Bow	30 Aug 92	22:40:45	79	61	16	12	2.1	1	10		1			7	2	4	7	3	S	100	500
159	Bow	30 Aug 92	23:33:27	133	125	23	20	4.3	1.5	10			1	7	2		4	7.5	3	S		700
160	Bow	30 Aug 92	23:37:02	270	254	42	40	6.0	1.5	10			1	7	2		4	7.5	3	S		700
161	Bow	30 Aug 92	23:39:29	111	111	24	16	4.4	1.5	10			1	7	2		4	7.5	3	S		700
162	Bow	30 Aug 92	23:44:12	95	95	17	14	0.4	1.5	10			1	7	2		4	7.5	3	S		700
163	Bow	30 Aug 92	23:48:55	147	127	44	32	4.0	1.5	10			1	7	2		4	7.5	3	S		700
164	Bow	30 Aug 92	23:50:58	85	80	17	17	2.1	1.5	10			1	7	2		4	7.5	3	S		700
165	Bow	30 Aug 92	23:59:16	118	113	20	18	5.4	1.5	10			1	7	2		4	7.5	3	S		700
166	Bow	31 Aug 92	0:01:19	90	90	13	13	1.9	1	10			2	5	3		3	6	1.75	S	100	700
167	Bow	31 Aug 92	0:24:52	178	141	44	26	5.1	1	10			2	5	3		3	6	1.75	S	100	700
168	Bow	31 Aug 92	0:37:19	199	199	45	30	4.4	1	10			2	5	3		3	6	1.75	S	100	700
169	Bow	31 Aug 92	1:33:58	131	90	25	22	7.2	0.75	10			1	5	4		3.5	6	1.5	S	150	450
170	Bow	31 Aug 92	1:58:39	105	76	21	16	3.6	0.75	10			1	5	4		3.5	6	1.5	S	150	450
171	Bow	31 Aug 92	2:06:09	230	230	34	34	3.9	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
172	Bow	31 Aug 92	2:12:40	89	77	31	18	4.1	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
173	Bow	31 Aug 92	2:15:35	153	121	36	23	5.0	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
174	Bow	31 Aug 92	2:32:40	103	101	36	20	5.8	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
175	Bow	31 Aug 92	2:36:27	126	72	25	24	5.4	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
176	Bow	31 Aug 92	2:38:54	213	189	32	32	3.2	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
177	Bow	31 Aug 92	2:43:51	177	149	62	26	5.2	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
178	Bow	31 Aug 92	2:44:24	213	146	64	34	2.3	0.5	10		2	1	6	3		3.5	6	1.5	S	100	500
179	Bow	31 Aug 92	3:15:21	152	94	58	36	7.6	0.2	10				7	3		3.5	5	1.25	S	100	500
180	Bow	31 Aug 92	3:23:55	227	224	70	58	7.7	0.2	10				7	3		3.5	5	1.25	S	100	500

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration								Level Ice Thickness			Ice Pressure	Floe Size	
										Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice							
Event No.	Hull Panel	Date	Time	Time of Pk Pres	Time of Pk Force	Max Local Load	Max Frame Load	Speed from GPS	Avg. Ship SOA	Total	(0 - .5 ft)	(.5 - 1 ft)	(1 - 2 ft)	(2 - 4 ft)	(4 - 6 ft)	(2nd Year & Multi-Year Ice)	Avg.	Max	Snow Depth	(None, Some, Extreme)	Avg.	Max
			(GMT)	(psi)	(psi)	(LT)	(LT)	(kt)	(kt)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(ft)	(ft)	(ft)		(ft)	(ft)
181	Bow	31 Aug 92	3:33:19	98	80	23	23	5.3	0.2	10												
182	Bow	31 Aug 92	3:41:00	360	343	68	65	4.9	0.2	10				7	3		3.5	5	1.25	S	100	500
183	Bow	31 Aug 92	4:02:24	175	174	37	26	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
184	Bow	31 Aug 92	4:23:48	252	244	75	39	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
185	Bow	31 Aug 92	4:44:04	169	169	39	25	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
186	Bow	31 Aug 92	4:50:01	191	160	78	31	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
187	Bow	31 Aug 92	4:52:40	123	110	48	19	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
188	Bow	31 Aug 92	5:02:19	113	88	34	18	Gap	0.3	10				7	3		3.5	5	1.25	S	100	500
189	Bow	31 Aug 92	5:52:32	98	98	21	15	Gap	0.3	10				7	3		3.5	5	1.25	S	100	500
190	Bow	31 Aug 92	6:02:30	147	125	31	22	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
191	Bow	31 Aug 92	6:19:46	188	145	46	32	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
192	Bow	31 Aug 92	6:31:55	196	196	30	29	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
193	Bow	31 Aug 92	6:40:51	229	200	48	36	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
194	Bow	31 Aug 92	6:56:03	185	185	48	31	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
195	Bow	31 Aug 92	7:02:41	92	71	17	15	Gap	0.2	10				7	3		3.5	5	1.25	S	100	500
196	Bow	31 Aug 92	7:12:42	151	142	57	31	Gap	0.2	10				8	2				2	S	100	300
197	Bow	31 Aug 92	7:15:35	170	141	35	25	Gap	0.2	10				8	2				2	S	100	300
198	Bow	31 Aug 92	7:18:40	229	229	36	34	Gap	0.2	10				8	2				2	S	100	300
199	Bow	31 Aug 92	7:20:27	115	86	27	18	Gap	0.2	10				8	2				2	S	100	300
200	Bow	31 Aug 92	7:22:33	229	229	50	34	Gap	0.2	10				8	2				2	S	100	300
201	Bow	31 Aug 92	7:37:14	147	147	22	22	Gap	0.2	10				8	2				2	S	100	300
202	Bow	31 Aug 92	7:42:25	307	300	70	50	Gap	0.2	10				8	2				2	S	100	300
203	Bow	31 Aug 92	7:45:50	74	74	24	13	Gap	0.2	10				8	2				2	S	100	300
204	Bow	31 Aug 92	7:50:28	164	156	38	31	Gap	0.2	10				8	2				2	S	100	300
205	Bow	31 Aug 92	8:08:15	396	297	75	61	Gap	0.3	10				8	2				2	S	100	300
206	Bow	31 Aug 92	8:53:37	95	87	16	14	Gap	0.3	10				8	2				2	S	100	300
207	Bow	31 Aug 92	8:56:02	199	192	32	32	Gap	0.3	10				8	2				2	S	100	300
208	Bow	31 Aug 92	9:13:50	251	251	37	37	Gap	0.3	10				8	2				2	S	100	300
209	Bow	31 Aug 92	9:15:28	187	165	77	35	Gap	0.3	10				8	2				2.5	S	100	200
210	Bow	31 Aug 92	9:19:29	347	222	64	52	Gap	0.3	10				8	2				2.5	S	100	200
211	Bow	31 Aug 92	9:22:33	107	107	16	16	Gap	0.3	10				8	2				2.5	S	100	200
212	Bow	31 Aug 92	9:25:11	252	197	43	37	Gap	0.3	10				8	2				2.5	S	100	200
213	Bow	31 Aug 92	9:29:13	104	86	21	15	Gap	0.3	10				8	2				2.5	S	100	200
214	Bow	31 Aug 92	9:35:44	130	99	32	21	Gap	0.3	10				8	2				2.5	S	100	200
215	Bow	31 Aug 92	9:45:22	284	186	52	42	Gap	0.3	10				8	2				2.5	S	100	200
216	Bow	31 Aug 92	9:48:45	112	112	17	17	Gap	0.3	10				8	2				2.5	S	100	200
217	Bow	31 Aug 92	9:51:13	128	128	25	24	Gap	0.3	10				8	2				2.5	S	100	200
218	Bow	31 Aug 92	10:02:27	91	91	17	14	Gap	0.2	10				8	2				2.5	S	100	200
219	Bow	31 Aug 92	10:18:30	148	84	31	22	Gap	0.2	10				8	2				2	S	50	300
220	Bow	31 Aug 92	10:23:36	263	263	94	41	Gap	0.2	10				8	2				2	S	50	300
221	Bow	31 Aug 92	10:31:31	335	335	85	50	Gap	0.2	10				8	2				2	S	50	300
222	Bow	31 Aug 92	13:25:12	145	140	55	30	Gap		10				8	2				2	S	50	300
223	Bow	31 Aug 92	13:31:30	88	76	17	13	Gap		10				8	2				2	S	50	300
224	Bow	31 Aug 92	13:46:55	465	302	96	82	6.6		10				8	2				2	S	50	300
225	Bow	31 Aug 92	13:54:54	192	139	42	29	6.2		10				8	2				2	S	50	300

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
226	Bow	31 Aug 92	13:58:03	121	96	24	18	7.8		10				8	2				2	S	50	300
227	Bow	31 Aug 92	14:04:40	117	117	18	18	5.8	Stopped	10				8	2				2	S	50	300
228	Bow	31 Aug 92	14:27:56	218	218	89	38	10.0	Stopped	10				8	2				2	S	50	300
229	Bow	31 Aug 92	16:53:09	302	193	100	45	7.6		10				8	2				2	S	50	900
230	Bow	31 Aug 92	16:56:46	141	124	69	24	9.2		10				8	2				2	S	50	900
231	Bow	31 Aug 92	17:00:45	230	230	63	34	11.7		10				8	2				2	S	60	1000
232	Bow	31 Aug 92	17:13:53	134	134	33	25	5.9		10				8	2				2	S	60	1000
233	Bow	31 Aug 92	17:20:29	149	109	36	23	0.8		10				8	2				2	S	60	1000
234	Bow	31 Aug 92	17:23:48	223	100	56	42	6.7		10				8	2				2	S	60	1000
235	Bow	31 Aug 92	17:35:54	153	108	44	28	6.2		10				8	2				2	S	60	1000
236	Bow	31 Aug 92	17:46:13	159	89	44	32	8.0		10				8	2				2	S	60	1000
237	Bow	31 Aug 92	17:50:35	130	130	28	19	3.2		10				8	2				2	S	60	1000
238	Bow	31 Aug 92	20:29:55	154	133	52	39	0.8		10				8	2				2	S	60	1000
239	Bow	31 Aug 92	20:30:22	153	134	73	24	1.7		10				8	2				2	S	60	1000
240	Side	31 Aug 92	20:30:22	277	269	54	50	1.7		10				8	2				2	S	60	1000
241	Side	31 Aug 92	20:37:36	573	365	97	74	0.8		10				8	2				2	S	60	1000
242	Trans	31 Aug 92	20:43:03	73	73	12	12	4.9		10				8	2				2	S	60	1000
243	Bow	31 Aug 92	20:45:39	140	66	36	21	6.3		10				8	2				2	S	60	1000
244	Side	31 Aug 92	20:51:48	107	95	19	14	Gap		10				8	2				2	S	60	1000
245	Bow	31 Aug 92	20:53:29	278	128	137	48	Gap		10				8	2				2	S	60	1000
246	Side	31 Aug 92	20:55:00	30	25	9	6	Gap		10				8	2				2	S	60	1000
247	Side	31 Aug 92	20:56:29	50	31	11	7	Gap		10				8	2				2	S	60	1000
248	Bow	31 Aug 92	20:59:09	125	88	66	19	Gap		10				8	2				2	S	60	1000
249	Side	31 Aug 92	20:59:09	47	47	12	12	Gap		10				8	2				2	S	50	800
250	Bow	31 Aug 92	21:00:10	90	90	14	13	Gap		10				8	2				2	S	50	800
251	Side	31 Aug 92	21:00:10	134	134	17	17	Gap		10				8	2				2	S	50	800
252	Trans	31 Aug 92	21:07:06	31	27	6	6	Gap		10				8	2				2	S	50	800
253	Bow	31 Aug 92	21:08:45	174	138	37	26	Gap		10				8	2				2	S	50	800
254	Side	31 Aug 92	21:08:45	96	96	15	12	Gap		10				8	2				2	S	50	800
255	Bow	31 Aug 92	21:10:28	148	145	41	22	Gap		10				8	2				2	S	50	800
256	Side	31 Aug 92	21:10:28	27	25	8	7	Gap		10				8	2				2	S	50	800
257	Bow	31 Aug 92	21:11:32	142	124	67	24	Gap		10				8	2				2	S	50	800
258	Bow	31 Aug 92	21:12:15	152	141	25	23	Gap		10				8	2				2	S	50	800
259	Side	31 Aug 92	21:12:15	88	88	15	15	Gap		10				8	2				2	S	50	800
260	Bow	31 Aug 92	21:15:16	148	148	40	22	Gap		10				8	2				2	S	50	800
261	Bow	31 Aug 92	21:18:24	72	33	23	11	Gap		10				8	2				2	S	50	800
262	Side	31 Aug 92	21:18:24	497	497	66	66	Gap		10				8	2				2	S	50	800
263	Bow	31 Aug 92	21:19:10	161	87	57	24	Gap		10				8	2				2	S	50	800
264	Bow	31 Aug 92	21:22:08	126	126	31	23	Gap		10				8	2				2	S	50	800
265	Bow	31 Aug 92	21:23:23	51	50	13	8	Gap		10				8	2				2	S	50	800
266	Side	31 Aug 92	21:23:23	53	30	9	7	Gap		10				8	2				2	S	50	800
267	Side	31 Aug 92	21:26:30	47	42	12	9	Gap		10				8	2				2	S	50	800
268	Bow	31 Aug 92	21:27:48	32	20	19	5	Gap		10				8	2				2	S	50	800
269	Side	31 Aug 92	21:27:48	55	55	7	7	Gap		10				8	2				2	S	50	800
270	Side	31 Aug 92	21:29:09	82	82	12	11	Gap		10				8	2				2	S	50	800

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
271	Bow	31 Aug 92	21:29:56	125	106	25	20	Gap		10												
272	Side	31 Aug 92	21:29:56	44	44	6	6	Gap		10				8	2				2	S	50	800
273	Trans	31 Aug 92	21:30:55	28	23	6	6	Gap		10				8	2				2	S	50	800
274	Side	31 Aug 92	21:31:38	12	12	2	2	Gap		10				8	2				2	S	50	800
275	Bow	31 Aug 92	21:32:14	194	194	37	29	Gap		10				8	2				2	S	50	800
276	Trans	31 Aug 92	21:37:13	15	10	4	4	3.0		10				8	2				2	S	50	800
277	Trans	31 Aug 92	21:42:08	38	29	8	8	Gap		10				8	2				2	S	50	800
278	Trans	31 Aug 92	21:44:13	169	169	36	36	Gap		10				8	2				2	S	50	800
279	Trans	31 Aug 92	21:46:29	124	124	20	20	Gap		10				8	2				2	S	50	800
280	Trans	31 Aug 92	21:57:08	256	256	41	41	6.8		10				8	2				2	S	50	800
281	Bow	31 Aug 92	21:58:09	179	179	72	27	5.3		10				8	2				2	S	50	800
282	Bow	31 Aug 92	22:02:04	181	73	53	29	4.6		10				8	2				2	S	50	800
283	Trans	31 Aug 92	22:04:33	55	55	9	9	1.1		10				8	2				2	S	50	700
284	Bow	31 Aug 92	22:05:25	265	129	74	39	5.0		10				8	2				2	S	50	700
285	Trans	31 Aug 92	22:07:49	25	22	6	6	3.5		10				8	2				2	S	50	700
286	Trans	31 Aug 92	22:14:13	31	26	10	10	5.7		10				8	2				2	S	50	700
287	Bow	31 Aug 92	22:29:34	392	392	73	65	3.5		10				8	2				2	S	50	700
288	Side	31 Aug 92	22:32:55	212	212	27	27	5.9		10				8	2				2	S	50	700
289	Bow	31 Aug 92	22:36:45	375	267	80	56	5.0		10				8	2				2	S	50	700
290	Trans	31 Aug 92	22:38:44	12	12	2	2	2.9		10				8	2				2	S	50	700
291	Bow	31 Aug 92	22:41:45	74	35	13	11	5.6		10				8	2				2	S	50	700
292	Side	31 Aug 92	22:41:45	24	21	4	3	5.6		10				8	2				2	S	50	700
293	Bow	31 Aug 92	23:18:31	253	178	74	38	4.2		10				8	2				2	S	50	700
294	Bow	31 Aug 92	23:19:00	197	162	107	33	4.7		10				8	2				2	S	80	1200
295	Side	31 Aug 92	23:27:20	60	44	15	10	1.7		10				8	2				2	S	80	1200
296	Bow	31 Aug 92	23:29:44	59	55	12	9	6.2		10				8	2				2	S	80	1200
297	Btm	31 Aug 92	23:29:44	82	82	47	34	6.2		10				8	2				2	S	80	1200
298	Bow	31 Aug 92	23:30:14	87	60	16	14	2.8		10				8	2				2	S	80	1200
299	Btm	31 Aug 92	23:31:06	37	37	10	10	1.9		10				8	2				2	S	80	1200
300	Bow	31 Aug 92	23:32:39	81	66	18	12	5.6		10				8	2				2	S	80	1200
301	Side	31 Aug 92	23:32:39	64	64	12	12	5.6		10				8	2				2	S	80	1200
302	Bow	31 Aug 92	23:35:04	12	11	4	2	4.0		10				8	2				2	S	80	1200
303	Side	31 Aug 92	23:35:04	30	30	7	7	4.0		10				8	2				2	S	80	1200
304	Trans	31 Aug 92	23:50:19	51	46	10	10	2.8		10				8	2				2	S	80	1200
305	Bow	31 Aug 92	23:51:07	103	85	24	15	3.5		10				8	2				2	S	80	1200
306	Bow	31 Aug 92	23:53:16	330	207	114	49	4.1		10				8	2				2	S	80	1200
307	Bow	31 Aug 92	23:58:36	619	444	198	107	4.4		10				8	2				2	S	80	1200
308	Bow	1 Sep 92	0:01:03	453	453	236	74	5.7	Varied	10				8	2				2	S	80	1200
309	Bow	1 Sep 92	0:03:16	143	143	21	21	3.6	Varied	10				8	2		3.5	5	2	S	100	1200
310	Side	1 Sep 92	0:03:16	166	166	40	40	3.6	Varied	10				8	2		3.5	5	2	S	100	1200
311	Bow	1 Sep 92	0:04:02	31	20	11	5	4.6	Varied	10				8	2		3.5	5	2	S	100	1200
312	Side	1 Sep 92	0:04:02	35	35	6	5	4.6	Varied	10				8	2		3.5	5	2	S	100	1200
313	Bow	1 Sep 92	0:08:36	177	142	43	30	5.2	Varied	10				8	2		3.5	5	2	S	100	1200
314	Side	1 Sep 92	0:09:51	69	50	13	10	6.4	Varied	10				8	2		3.5	5	2	S	100	1200
315	Trans	1 Sep 92	0:11:41	63	63	10	10	2.5	Varied	10				8	2		3.5	5	2	S	100	1200

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration							Level Ice Thickness			Ice Pressure	Floe Size	
										Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice						
Event No.	Hull Panel	Date	Time	Time of Pk Pres	Time of Pk Force	Max Local Load	Max Frame Load	Speed from GPS	Avg. Ship SOA	Total	(0 - .5 ft)	(.5 - 1 ft)	(1 - 2 ft)	(2 - 4 ft)	(4 - 6 ft)	(2nd Year & Multi-Year Ice)	Avg.	Max	Snow Depth	(None, Some, Extreme)	Avg.	Max
			(GMT)	(psi)	(psi)	(LT)	(LT)	(kt)	(kt)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(ft)	(ft)	(ft)		(ft)	(ft)
316	Side	1 Sep 92	0:13:53	99	82	17	16	2.3	Varied	10				8	2		3.5	5	2	S	100	1200
317	Bow	1 Sep 92	0:16:03	291	184	152	43	5.8	Varied	10				8	2		3.5	5	2	S	100	1200
318	Side	1 Sep 92	0:16:58	401	398	68	64	2.1	Varied	10				8	2		3.5	5	2	S	100	1200
319	Bow	1 Sep 92	0:19:01	81	65	52	19	5.0	Varied	10				8	2		3.5	5	2	S	100	1200
320	Side	1 Sep 92	0:20:14	110	98	15	14	1.8	Varied	10				8	2		3.5	5	2	S	100	1200
321	Bow	1 Sep 92	0:21:56	217	186	61	34	5.2	Varied	10				8	2		3.5	5	2	S	100	1200
322	Bow	1 Sep 92	0:31:02	313	222	123	47	6.5	Varied	10				8	2		3.5	5	2	S	100	1200
323	Bow	1 Sep 92	0:34:10	77	54	27	16	4.0	Varied	10				8	2		3.5	5	2	S	100	1200
324	Side	1 Sep 92	0:34:10	102	102	14	14	4.0	Varied	10				8	2		3.5	5	2	S	100	1200
325	Bow	1 Sep 92	1:01:42	71	32	13	12	6.2														
326	Side	1 Sep 92	1:01:42	212	212	53	52	6.2														
327	Side	1 Sep 92	1:04:53	61	54	12	9	5.1														
328	Bow	1 Sep 92	1:05:27	40	35	21	9	6.4														
329	Side	1 Sep 92	1:05:27	75	37	14	12	6.4														
330	Side	1 Sep 92	1:06:16	239	228	37	35	3.3														
331	Side	1 Sep 92	1:07:30	51	40	10	9	6.2														
332	Bow	1 Sep 92	1:08:55	155	72	31	23	0.6														
333	Side	1 Sep 92	1:10:57	84	84	11	11	4.5														
334	Bow	1 Sep 92	1:11:28	52	46	40	11	6.2														
335	Side	1 Sep 92	1:11:28	231	187	46	40	6.2														
336	Trans	1 Sep 92	1:15:30	256	256	41	41	4.0														
337	Bow	1 Sep 92	1:16:50	196	196	53	35	4.9														
338	Bow	1 Sep 92	1:21:58	51	39	18	10	6.1														
339	Side	1 Sep 92	1:21:58	86	86	12	12	6.1														
340	Bow	1 Sep 92	1:25:31	148	133	40	28	4.5														
341	Bow	1 Sep 92	1:31:16	106	68	23	16	6.4														
342	Side	1 Sep 92	1:32:32	23	18	5	4	0.2														
343	Trans	1 Sep 92	1:37:03	122	122	20	20	4.4														
344	Bow	1 Sep 92	1:38:24	270	270	179	59	6.0														
345	Bow	1 Sep 92	1:39:37	143	114	52	21	1.1														
346	Bow	1 Sep 92	1:41:36	219	219	33	33	6.7														
347	Side	1 Sep 92	1:45:21	259	100	34	33	0.5														
348	Bow	1 Sep 92	10:39:23	226	97	81	34	No Fix	Varied	10				8	2		3.5	4	2	5	100	1200
349	Bow	1 Sep 92	10:42:04	259	176	172	42	No Fix	Varied	10				8	2		3.5	4	2	5	100	1200
350	Bow	1 Sep 92	10:45:03	447	199	147	66	No Fix	Varied	10				8	2		3.5	4	2	5	100	1200
351	Trans	1 Sep 92	10:56:30	75	75	12	12	No Fix	Varied	10				8	2		3.5	4	2	5	100	1200
352	Bow	1 Sep 92	10:57:45	30	15	7	5	No Fix	Varied	10				8	2		3.5	4	2	5	100	1200
353	Side	1 Sep 92	10:57:45	126	86	22	18	No Fix	Varied	10				8	2		3.5	4	2	5	100	1200
354	Bow	1 Sep 92	11:17:27	116	85	31	18	5.5														
355	Bow	1 Sep 92	11:30:15	42	11	10	6	7.3														
356	Side	1 Sep 92	11:30:15	62	33	10	9	7.3														
357	Side	1 Sep 92	11:34:12	92	91	43	22	8.4														
358	Side	1 Sep 92	11:44:01	48	48	10	7	7.1														
359	Trans	1 Sep 92	11:55:28	130	130	21	21	5.8														
360	Side	1 Sep 92	12:00:24	68	64	12	12	3.4	0													

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	New and Grey Ice (0 - .5 ft) (Tenths)	Grey-White (.5 - 1 ft) (Tenths)	First Yr Thin Ice (1 - 2 ft) (Tenths)	First Yr Med. Ice (2 - 4 ft) (Tenths)	First Yr Thick Ice (4 - 6 ft) (Tenths)	Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness Avg. (ft)	Level Ice Thickness Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size Avg. (ft)	Floe Size Max (ft)
361	Trans	1 Sep 92	12:06:42	77	77	12	12	7.4	0													
362	Trans	1 Sep 92	12:13:00	82	82	17	17	4.5	0													
363	Side	1 Sep 92	14:54:52	496	482	123	83	1.6														
364	Trans	1 Sep 92	14:55:26	16	12	4	4	0.5														
365	Side	1 Sep 92	14:56:05	403	403	52	52	3.4														
366	Bow	1 Sep 92	14:58:49	249	232	91	40	6.6														
367	Side	1 Sep 92	15:08:25	266	266	34	34	7.4	0.25	10				8	2				1.5	S	100	600
368	Trans	1 Sep 92	15:15:18	42	42	7	7	3.5	0.25	10				8	2				1.5	S	100	600
369	Bow	1 Sep 92	15:21:55	155	26	49	23	5.9	0.25	10				8	2				1.5	S	100	600
370	Bow	1 Sep 92	15:26:48	341	147	94	55	8.3	0.25	10				8	2				1.5	S	100	600
371	Bow	1 Sep 92	15:35:45	32	24	6	5	1.5	0.25	10				8	2				1.5	S	100	600
372	Bow	1 Sep 92	15:39:22	163	96	62	27	8.1	0.25	10				8	2				1.5	S	100	600
373	Side	1 Sep 92	16:11:21	57	43	8	7	No Fix	0.5	10				8	2				2	S	50	800
374	Bow	1 Sep 92	16:11:52	234	155	46	35	No Fix	0.5	10				8	2				2	S	50	800
375	Side	1 Sep 92	16:11:52	338	327	83	46	No Fix	0.5	10				8	2				2	S	50	800
376	Bow	1 Sep 92	16:15:05	35	21	16	5	No Fix	0.5	10				8	2				2	S	50	800
377	Side	1 Sep 92	16:15:05	125	120	26	21	No Fix	0.5	10				8	2				2	S	50	800
378	Side	1 Sep 92	16:16:48	565	565	73	73	No Fix	0.5	10				8	2				2	S	50	800
379	Side	1 Sep 92	16:22:36	150	150	23	23	No Fix	0.5	10				8	2				2	S	50	800
380	Side	1 Sep 92	16:26:14	136	132	20	17	No Fix	0.5	10				8	2				2	S	50	800
381	Trans	1 Sep 92	16:29:11	70	70	11	11	No Fix	0.5	10				8	2				2	S	50	800
382	Bow	1 Sep 92	16:30:12	137	110	52	20	No Fix	0.5	10				8	2				2	S	50	800
383	Btm	1 Sep 92	16:30:12	23	23	8	6	No Fix	0.5	10				8	2				2	S	50	800
384	Side	1 Sep 92	16:32:26	49	38	10	9	No Fix	0.5	10				8	2				2	S	50	800
385	Trans	1 Sep 92	16:32:26	49	49	8	8	No Fix	0.5	10				8	2				2	S	50	800
386	Bow	1 Sep 92	16:33:57	31	12	10	5	No Fix	0.5	10				8	2				2	S	50	800
387	Side	1 Sep 92	16:33:57	41	41	5	5	No Fix	0.5	10				8	2				2	S	50	800
388	Bow	1 Sep 92	16:34:50	106	75	62	16	No Fix	0.5	10				8	2				2	S	50	800
389	Bow	1 Sep 92	16:37:11	52	15	14	8	No Fix	0.5	10				8	2				2	S	50	800
390	Side	1 Sep 92	16:37:11	170	170	22	22	No Fix	0.5	10				8	2				2	S	50	800
391	Bow	1 Sep 92	16:39:23	172	172	61	26	No Fix	0.5	10				8	2				2	S	50	800
392	Side	1 Sep 92	16:39:23	118	118	15	15	No Fix	0.5	10				8	2				2	S	50	800
393	Side	1 Sep 92	16:44:14	96	64	18	13	No Fix	0.5	10				8	2				2	S	50	800
394	Bow	1 Sep 92	16:53:55	259	257	70	51	5.4	0.5	10				8	2				2	S	50	800
395	Side	1 Sep 92	16:53:55	667	667	86	86	5.4	0.5	10				8	2				2	S	50	800
396	Side	1 Sep 92	16:56:45	484	484	62	62	5.3	0.5	10				8	2				2	S	50	800
397	Bow	1 Sep 92	16:57:21	47	44	34	8	4.9	0.5	10				8	2				2	S	50	800
398	Btm	1 Sep 92	16:57:21	26	26	8	8	4.9	0.5	10				8	2				2	S	50	800
399	Side	1 Sep 92	17:02:34	64	63	11	10	2.4	0.2	10				8	2				2	S	50	800
400	Bow	1 Sep 92	17:05:19	167	109	48	26	3.0	0.2	10				8	2				2	S	50	800
401	Side	1 Sep 92	17:07:40	519	519	80	75	2.5	0.2	10				8	2				2	S	50	800
402	Bow	1 Sep 92	17:11:29	296	296	74	61	—	0.2	10				8	2				2	S	50	800
403	Side	1 Sep 92	17:13:42	30	20	11	9	2.5	0.2	10				8	2				2	S	50	800
404	Bow	1 Sep 92	17:14:46	149	149	22	22	3.3	0.2	10				8	2				2	S	50	800
405	Side	1 Sep 92	17:14:46	715	715	136	136	3.3	0.2	10				8	2				2	S	50	800

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
406	Bow	1 Sep 92	17:16:26	64	64	11	10	5.7	0.2	10				8	2				2	S	50	800
407	Side	1 Sep 92	17:16:26	132	132	17	17	5.7	0.2	10				8	2				2	S	50	800
408	Bow	1 Sep 92	17:25:20	302	247	71	55	3.7	0.2	10				8	2				2	S	50	800
409	Bow	1 Sep 92	17:27:44	240	179	70	36	3.5	0.2	10				8	2				2	S	50	800
410	Btm	1 Sep 92	17:27:44	39	39	23	13	3.5	0.2	10				8	2				2	S	50	800
411	Side	1 Sep 92	17:29:41	132	132	26	17	3.1	0.2	10				8	2				2	S	50	800
412	Side	1 Sep 92	17:30:34	177	177	25	23	6.7	0.2	10				8	2				2	S	50	800
413	Trans	1 Sep 92	17:32:08	67	67	11	11	6.3	0.2	10				8	2				2	S	50	800
414	Bow	1 Sep 92	17:33:17	271	129	62	43	4.4	0.2	10				8	2				2	S	50	800
415	Side	1 Sep 92	17:35:52	137	133	28	18	3.2	0.2	10				8	2				2	S	50	800
416	Bow	1 Sep 92	17:36:38	27	18	6	4	2.5	0.2	10				8	2				2	S	50	800
417	Trans	1 Sep 92	17:36:38	26	24	6	6	2.5	0.2	10				8	2				2	S	50	800
418	Bow	1 Sep 92	17:38:16	182	182	56	27	4.0	0.2	10				8	2				2	S	50	800
419	Bow	1 Sep 92	17:41:27	33	12	8	5	2.1	0.2	10				8	2				2	S	50	800
420	Side	1 Sep 92	17:41:27	61	25	10	8	2.1	0.2	10				8	2				2	S	50	800
421	Side	1 Sep 92	17:44:16	43	39	7	7	2.5	0.2	10				8	2				2	S	50	800
422	Side	1 Sep 92	17:45:13	378	314	71	51	2.7	0.2	10				8	2				2	S	50	800
423	Bow	1 Sep 92	17:46:54	471	326	125	78	5.4	0.2	10				8	2				2	S	50	800
424	Side	1 Sep 92	17:48:47	262	246	68	62	3.1	0.2	10				8	2				2	S	50	800
425	Bow	1 Sep 92	17:50:13	243	220	57	36	9.2	0.2	10				8	2				2	S	50	800
426	Trans	1 Sep 92	17:50:13	29	27	7	7	9.2	0.2	10				8	2				2	S	50	800
427	Side	1 Sep 92	17:51:39	229	164	61	34	1.2	0.2	10				8	2				2	S	50	800
428	Bow	1 Sep 92	17:53:18	91	44	17	14	5.7	0.2	10				8	2				2	S	50	800
429	Side	1 Sep 92	17:53:18	60	60	13	13	5.7	0.2	10				8	2				2	S	50	800
430	Side	1 Sep 92	17:54:51	411	411	53	53	2.7	0.2	10				8	2				2	S	50	800
431	Bow	1 Sep 92	17:59:36	114	112	38	17	4.4	0.2	10				8	2				2	S	50	800
432	Bow	1 Sep 92	18:05:36	31	14	11	6	6.9	0.5	10				8	2				1.5	S	50	800
433	Side	1 Sep 92	18:05:36	230	230	32	32	6.9	0.5	10				8	2				1.5	S	50	800
434	Side	1 Sep 92	18:08:08	381	321	50	49	5.0	0.5	10				8	2				1.5	S	50	800
435	Bow	1 Sep 92	18:12:31	201	158	99	32	4.4	0.5	10				8	2				1.5	S	50	800
436	Bow	1 Sep 92	18:14:53	41	29	17	10	5.4	0.5	10				8	2				1.5	S	50	800
437	Side	1 Sep 92	18:14:53	38	38	5	5	5.4	0.5	10				8	2				1.5	S	50	800
438	Bow	1 Sep 92	18:17:25	193	106	62	29	3.7	0.5	10				8	2				1.5	S	50	800
439	Bow	1 Sep 92	18:18:25	38	26	13	6	4.8	0.5	10				8	2				1.5	S	50	800
440	Bow	1 Sep 92	18:18:57	42	36	20	8	4.0	0.5	10				8	2				1.5	S	50	800
441	Side	1 Sep 92	18:18:57	79	76	21	17	4.0	0.5	10				8	2				1.5	S	50	800
442	Bow	1 Sep 92	18:20:10	349	343	73	53	3.5	0.5	10				8	2				1.5	S	50	800
443	Side	1 Sep 92	18:22:40	219	219	38	35	4.4	0.5	10				8	2				1.5	S	50	800
444	Bow	1 Sep 92	18:23:29	155	150	65	23	5.2	0.5	10				8	2				1.5	S	50	800
445	Side	1 Sep 92	18:23:29	47	37	9	9	5.2	0.5	10				8	2				1.5	S	50	800
446	Bow	1 Sep 92	18:26:39	174	52	38	26	4.5	0.5	10				8	2				1.5	S	50	800
447	Side	1 Sep 92	18:26:39	63	63	8	8	4.5	0.5	10				8	2				1.5	S	50	800
448	Side	1 Sep 92	18:27:54	115	115	15	15	2.5	0.5	10				8	2				1.5	S	50	800
449	Trans	1 Sep 92	18:27:54	115	115	18	18	2.5	0.5	10				8	2				1.5	S	50	800
450	Trans	1 Sep 92	18:29:53	29	29	5	5	0.8	0.5	10				8	2				1.5	S	50	800

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
451	Bow	1 Sep 92	18:34:41	81	70	21	12	3.2	0.5	10				8	2				1.5	S	50	800
452	Trans	1 Sep 92	18:36:55	36	36	6	6	2.1	0.5	10				8	2				1.5	S	50	800
453	Bow	1 Sep 92	18:39:18	129	103	46	28	Gap	0.5	10				8	2				1.5	S	50	800
454	Side	1 Sep 92	18:40:27	188	188	24	24	Gap	0.5	10				8	2				1.5	S	50	800
455	Bow	1 Sep 92	18:44:25	102	89	32	16	Gap	0.5	10				8	2				1.5	S	50	800
456	Side	1 Sep 92	18:44:25	132	112	25	25	Gap	0.5	10				8	2				1.5	S	50	800
457	Bow	1 Sep 92	18:45:33	105	85	49	37	Gap	0.5	10				8	2				1.5	S	50	800
458	Bow	1 Sep 92	18:47:30	89	77	15	13	Gap	0.5	10				8	2				1.5	S	50	800
459	Side	1 Sep 92	18:47:30	195	125	37	35	Gap	0.5	10				8	2				1.5	S	50	800
460	Bow	1 Sep 92	18:49:05	132	68	38	26	Gap	0.5	10				8	2				1.5	S	50	800
461	Bow	1 Sep 92	18:51:40	225	139	45	33	No Fix	0.5	10				8	2				1.5	S	50	800
462	Bow	1 Sep 92	18:55:40	77	53	18	13	No Fix	0.5	10				8	2				1.5	S	50	800
463	Side	1 Sep 92	18:56:13	438	270	65	65	No Fix	0.5	10				8	2				1.5	S	50	800
464	Side	1 Sep 92	18:58:36	125	124	27	27	No Fix	0.5	10				8	2				1.5	S	50	800
465	Bow	1 Sep 92	19:00:02	102	97	20	16	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
466	Side	1 Sep 92	19:00:02	229	223	35	33	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
467	Bow	1 Sep 92	19:00:55	159	152	31	24	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
468	Bow	1 Sep 92	19:01:39	244	230	64	38	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
469	Bow	1 Sep 92	19:04:32	90	90	13	13	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
470	Side	1 Sep 92	19:04:32	69	56	14	9	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
471	Bow	1 Sep 92	19:05:08	28	19	14	5	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
472	Side	1 Sep 92	19:05:08	97	97	16	16	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
473	Btm	1 Sep 92	19:07:35	55	55	15	14	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
474	Trans	1 Sep 92	19:07:35	17	14	3	3	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
475	Bow	1 Sep 92	19:08:59	19	5	4	3	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
476	Side	1 Sep 92	19:08:59	71	43	16	11	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
477	Bow	1 Sep 92	19:10:36	76	76	14	11	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
478	Side	1 Sep 92	19:10:36	38	35	5	5	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
479	Side	1 Sep 92	19:11:05	171	145	29	22	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
480	Trans	1 Sep 92	19:11:05	23	11	4	4	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
481	Side	1 Sep 92	19:11:38	101	99	15	15	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
482	Bow	1 Sep 92	19:12:15	139	114	48	21	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
483	Side	1 Sep 92	19:12:15	29	28	5	4	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
484	Side	1 Sep 92	19:14:32	144	133	32	26	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
485	Bow	1 Sep 92	19:15:06	70	45	19	11	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
486	Side	1 Sep 92	19:15:06	40	40	7	5	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
487	Side	1 Sep 92	19:19:50	203	203	30	30	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
488	Trans	1 Sep 92	19:19:50	65	65	10	10	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
489	Side	1 Sep 92	19:34:35	174	174	31	29	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
490	Trans	1 Sep 92	19:36:14	93	93	15	15	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
491	Bow	1 Sep 92	19:45:17	72	72	21	11	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
492	Side	1 Sep 92	19:45:17	173	128	35	23	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
493	Bow	1 Sep 92	19:47:54	112	112	27	19	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
494	Trans	1 Sep 92	19:55:26	53	50	13	13	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
495	Bow	1 Sep 92	19:56:11	142	61	27	21	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	New and Grey Ice (0 - .5 ft) (Tenths)	Grey-White (.5 - 1 ft) (Tenths)	First Yr Thin Ice (1 - 2 ft) (Tenths)	First Yr Med. Ice (2 - 4 ft) (Tenths)	First Yr Thick Ice (4 - 6 ft) (Tenths)	Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness Avg. (ft)	Level Ice Thickness Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size Avg. (ft)	Floe Size Max (ft)
496	Bow	1 Sep 92	19:58:33	50	39	12	7	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
497	Btm	1 Sep 92	19:58:33	61	61	20	20	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
498	Side	1 Sep 92	19:58:33	24	24	4	3	No Fix	0.3	10			1	7	2		3	6	1.5	S	150	400
499	Bow	1 Sep 92	20:00:44	276	111	49	42	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
500	Trans	1 Sep 92	20:17:04	61	61	10	10	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
501	Bow	1 Sep 92	20:22:50	283	102	67	42	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
502	Bow	1 Sep 92	20:26:05	157	141	55	26	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
503	Bow	1 Sep 92	20:26:58	301	204	95	63	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
504	Bow	1 Sep 92	20:28:20	316	128	75	67	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
505	Side	1 Sep 92	20:33:29	89	47	20	16	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
506	Bow	1 Sep 92	20:35:17	121	89	37	20	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
507	Bow	1 Sep 92	20:40:27	85	40	23	13	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
508	Trans	1 Sep 92	20:43:12	57	57	9	9	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
509	Side	1 Sep 92	20:49:00	82	82	11	11	No Fix	0.75	10			1	7	2		3	6	1.5	S	150	600
510	Bow	1 Sep 92	20:51:05	53	42	18	9	2.3	0.75	10			1	7	2		3	6	1.5	S	150	600
511	Side	1 Sep 92	20:51:05	185	184	33	27	2.3	0.75	10			1	7	2		3	6	1.5	S	150	600
512	Bow	1 Sep 92	20:51:34	89	28	19	13	1.8	0.75	10			1	7	2		3	6	1.5	S	150	600
513	Side	1 Sep 92	20:51:34	133	65	23	20	1.8	0.75	10			1	7	2		3	6	1.5	S	150	600
514	Side	1 Sep 92	20:53:03	158	111	27	25	1.2	0.75	10			1	7	2		3	6	1.5	S	150	600
515	Bow	1 Sep 92	21:14:25	58	36	11	9	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
516	Btm	1 Sep 92	21:14:25	14	7	6	4	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
517	Bow	1 Sep 92	21:15:34	135	75	65	25	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
518	Bow	1 Sep 92	21:20:27	267	125	60	40	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
519	Bow	1 Sep 92	21:21:26	207	166	38	31	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
520	Bow	1 Sep 92	21:21:54	90	86	16	13	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
521	Bow	1 Sep 92	21:25:52	46	30	7	7	No Fix	0.6	9.5			2	7	1		3	6	1	S	100	400
522	Bow	1 Sep 92	23:15:03	186	111	83	28	—	4	10			1	7	2		3	5	1.5	S	60	800
523	Bow	1 Sep 92	23:24:33	80	41	27	12	5.6	4	10			1	7	2		3	5	1.5	S	60	800
524	Btm	1 Sep 92	23:24:33	89	47	32	25	5.6	4	10			1	7	2		3	5	1.5	S	60	800
525	Bow	1 Sep 92	23:34:55	143	80	47	21	7.2	4	10			1	7	2		3	5	1.5	S	60	800
526	Bow	1 Sep 92	23:36:27	137	83	31	20	—	4	10			1	7	2		3	5	1.5	S	60	800
527	Bow	2 Sep 92	0:00:35	302	302	67	47	Gap	3	10						10	3.5	4	1.5	S	600	600
528	Bow	2 Sep 92	0:03:35	79	12	23	17	Gap	3	10						10	3.5	4	1.5	S	600	600
529	Side	2 Sep 92	0:03:35	79	64	17	17	Gap	3	10						10	3.5	4	1.5	S	600	600
530	Side	2 Sep 92	0:35:14	81	56	20	14	Gap	3	10						10	3.5	4	1.5	S	600	600
531	Bow	2 Sep 92	0:36:30	60	16	33	9	Gap	3	10						10	3.5	4	1.5	S	600	600
532	Side	2 Sep 92	0:36:30	153	142	42	22	Gap	3	10						10	3.5	4	1.5	S	600	600
533	Bow	2 Sep 92	0:38:55	151	94	39	22	Gap	3	10						10	3.5	4	1.5	S	600	600
534	Btm	2 Sep 92	0:38:55	27	27	7	7	Gap	3	10						10	3.5	4	1.5	S	600	600
535	Side	2 Sep 92	0:38:55	60	60	16	9	Gap	3	10						10	3.5	4	1.5	S	600	600
536	Bow	2 Sep 92	0:44:21	50	16	12	7	Gap	3	10						10	3.5	4	1.5	S	600	600
537	Side	2 Sep 92	0:44:21	52	42	20	15	Gap	3	10						10	3.5	4	1.5	S	600	600
538	Side	2 Sep 92	0:49:53	679	622	123	107	Gap	3	10						10	3.5	4	1.5	S	600	600
539	Bow	2 Sep 92	0:53:59	72	69	53	19	Gap	3	10						10	3.5	4	1.5	S	600	600
540	Bow	2 Sep 92	1:00:37	66	66	23	10	Gap	1	10				5	5		3.5	4	2	S	150	150

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration: Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice	Level Ice Thickness			Ice Pressure	Floe Size	
Event No.	Hull Panel	Date	Time	Time of Pk Pres	Time of Pk Force	Max Local Load	Max Frame Load	Speed from GPS	Avg. Ship SOA	Total	(0 - .5 ft)	(.5 - 1 ft)	(1 - 2 ft)	(2 - 4 ft)	(4 - 6 ft)	(2nd Year & Multi-Year Ice)	Avg.	Max	Snow Depth	(None, Some, Extreme)	Avg.	Max
			(GMT)	(psi)	(psi)	(LT)	(LT)	(kt)	(kt)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(ft)	(ft)	(ft)		(ft)	(ft)
541	Side	2 Sep 92	1:00:37	97	97	12	12	Gap	1	10				5	5		3.5	4	2	S	150	150
542	Trans	2 Sep 92	1:09:40	55	55	9	9	Gap	1	10				5	5		3.5	4	2	S	150	150
543	Trans	2 Sep 92	1:13:14	33	17	6	6	Gap	1	10				5	5		3.5	4	2	S	150	150
544	Bow	2 Sep 92	1:23:48	274	225	48	41	4.7	1	10				5	5		3.5	4	2	S	150	150
545	Trans	2 Sep 92	1:30:15	86	86	14	14	3.5	1	10				5	5		3.5	4	2	S	150	150
546	Side	2 Sep 92	1:35:47	138	129	20	18	3.6	1	10				5	5		3.5	4	2	S	150	150
547	Trans	2 Sep 92	1:40:14	18	18	4	4	2.8	1	10				5	5		3.5	4	2	S	150	150
548	Trans	2 Sep 92	1:45:58	42	35	11	11	2.4	1	10				5	5		3.5	4	2	S	150	150
549	Bow	2 Sep 92	1:48:13	142	111	39	21	2.5	1	10				5	5		3.5	4	2	S	150	150
550	Trans	2 Sep 92	1:54:22	39	23	7	7	1.7	1	10				5	5		3.5	4	2	S	150	150
551	Bow	2 Sep 92	1:56:57	71	43	24	15	4.2	1	10				5	5		3.5	4	2	S	150	150
552	Side	2 Sep 92	1:56:57	65	65	10	10	4.2	1	10				5	5		3.5	4	2	S	150	150
553	Trans	2 Sep 92	2:00:32	74	74	13	13	3.3	0													
554	Trans	2 Sep 92	4:51:36	49	46	10	10	Gap		10			2	5	2		3.5	4	2	N	150	600
555	Side	2 Sep 92	4:52:15	87	71	14	14	Gap		10			2	5	2		3.5	4	2	N	150	600
556	Bow	2 Sep 92	4:54:26	266	262	73	44	Gap		10			2	5	2		3.5	4	2	N	150	600
557	Bow	2 Sep 92	4:55:08	24	24	4	4	Gap		10			2	5	2		3.5	4	2	N	150	600
558	Side	2 Sep 92	4:55:08	63	38	17	8	Gap		10			2	5	2		3.5	4	2	N	150	600
559	Bow	2 Sep 92	4:56:59	85	41	21	13	Gap		10			2	5	2		3.5	4	2	N	150	600
560	Side	2 Sep 92	4:56:59	37	18	7	5	Gap		10			2	5	2		3.5	4	2	N	150	600
561	Bow	2 Sep 92	4:57:39	41	41	12	6	Gap		10			2	5	2		3.5	4	2	N	150	600
562	Side	2 Sep 92	4:57:39	116	113	19	15	Gap		10			2	5	2		3.5	4	2	N	150	600
563	Bow	2 Sep 92	5:00:33	367	197	71	55	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
564	Trans	2 Sep 92	5:02:31	100	100	16	16	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
565	Bow	2 Sep 92	5:03:28	314	260	104	72	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
566	Bow	2 Sep 92	5:07:05	38	16	12	6	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
567	Side	2 Sep 92	5:07:05	39	31	5	5	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
568	Bow	2 Sep 92	5:09:22	127	98	39	24	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
569	Side	2 Sep 92	5:09:22	103	101	18	15	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
570	Trans	2 Sep 92	5:20:29	28	25	5	5	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
571	Bow	2 Sep 92	5:23:56	71	53	13	11	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
572	Side	2 Sep 92	5:23:56	55	53	10	9	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
573	Bow	2 Sep 92	5:26:12	261	166	48	39	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
574	Bow	2 Sep 92	5:28:28	60	46	54	26	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
575	Bow	2 Sep 92	5:40:59	82	54	31	13	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
576	Bow	2 Sep 92	5:44:37	121	112	23	19	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
577	Side	2 Sep 92	5:44:37	52	52	10	10	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
578	Side	2 Sep 92	5:45:12	45	45	8	8	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
579	Bow	2 Sep 92	5:49:52	180	137	36	28	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
580	Side	2 Sep 92	5:51:03	109	109	14	14	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
581	Bow	2 Sep 92	5:55:14	148	116	39	27	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
582	Bow	2 Sep 92	5:56:10	265	207	66	39	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
583	Bow	2 Sep 92	5:56:41	119	89	18	18	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
584	Side	2 Sep 92	5:56:41	98	98	17	17	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
585	Side	2 Sep 92	5:57:13	69	69	11	11	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
586	Bow	2 Sep 92	5:59:10	109	96	27	22	Gap	2.5	10			2	5	2		3.5	4	2	N	150	300
587	Bow	2 Sep 92	6:00:35	153	90	48	23	Gap		10				5	5		3.5	4	2	S	150	300
588	Bow	2 Sep 92	6:01:55	165	125	34	25	Gap		10				5	5		3.5	4	2	S	150	300
589	Bow	2 Sep 92	6:02:38	122	33	47	18	Gap		10				5	5		3.5	4	2	S	150	300
590	Bow	2 Sep 92	6:03:16	41	22	8	6	Gap		10				5	5		3.5	4	2	S	150	300
591	Side	2 Sep 92	6:03:16	44	44	6	6	Gap		10				5	5		3.5	4	2	S	150	300
592	Side	2 Sep 92	6:14:07	73	50	10	9	Gap		10				5	5		3.5	4	2	S	150	300
593	Side	2 Sep 92	6:18:45	23	19	4	3	Gap		10				5	5		3.5	4	2	S	150	300
594	Side	2 Sep 92	6:19:29	116	101	19	16	Gap		10				5	5		3.5	4	2	S	150	300
595	Trans	2 Sep 92	6:23:57	122	122	30	30	Gap		10				5	5		3.5	4	2	S	150	300
596	Side	2 Sep 92	6:24:40	66	66	8	8	Gap		10				5	5		3.5	4	2	S	150	300
597	Bow	2 Sep 92	6:25:16	159	159	24	24	Gap		10				5	5		3.5	4	2	S	150	300
598	Side	2 Sep 92	6:26:00	26	18	4	4	Gap		10				5	5		3.5	4	2	S	150	300
599	Side	2 Sep 92	6:27:18	66	53	10	8	Gap		10				5	5		3.5	4	2	S	150	300
600	Bow	2 Sep 92	6:28:01	77	39	23	11	Gap		10				5	5		3.5	4	2	S	150	300
601	Side	2 Sep 92	6:28:01	28	28	5	5	Gap		10				5	5		3.5	4	2	S	150	300
602	Side	2 Sep 92	6:31:58	35	28	7	7	Gap		10				5	5		3.5	4	2	S	150	300
603	Side	2 Sep 92	6:34:15	126	109	21	21	Gap		10				5	5		3.5	4	2	S	150	300
604	Trans	2 Sep 92	6:34:15	348	348	56	56	Gap		10				5	5		3.5	4	2	S	150	300
605	Trans	2 Sep 92	6:36:20	131	115	24	24	Gap		10				5	5		3.5	4	2	S	150	300
606	Bow	2 Sep 92	6:45:16	230	148	93	34	Gap		10				5	5		3.5	4	2	S	150	300
607	Side	2 Sep 92	6:45:48	172	146	28	26	Gap		10				5	5		3.5	4	2	S	150	300
608	Bow	2 Sep 92	6:49:40	195	167	45	39	Gap		10				5	5		3.5	4	2	S	150	300
609	Side	2 Sep 92	6:54:50	75	58	12	11	Gap		10				5	5		3.5	4	2	S	150	300
610	Bow	2 Sep 92	6:56:14	55	55	18	9	Gap		10				5	5		3.5	4	2	S	150	300
611	Side	2 Sep 92	10:29:04	265	234	50	43	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
612	Side	2 Sep 92	10:30:57	105	100	26	17	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
613	Bow	2 Sep 92	10:32:27	75	31	17	11	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
614	Side	2 Sep 92	10:32:27	78	78	12	12	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
615	Bow	2 Sep 92	10:35:02	224	189	64	34	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
616	Side	2 Sep 92	10:35:02	223	223	31	29	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
617	Bow	2 Sep 92	10:37:18	170	165	34	25	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
618	Bow	2 Sep 92	10:38:18	254	225	46	38	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
619	Side	2 Sep 92	10:38:18	68	67	11	10	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
620	Bow	2 Sep 92	10:41:18	363	363	56	54	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
621	Side	2 Sep 92	10:41:18	143	143	18	18	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
622	Side	2 Sep 92	10:43:38	77	77	10	10	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
623	Side	2 Sep 92	10:44:14	184	155	32	32	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
624	Side	2 Sep 92	10:44:54	290	262	83	64	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
625	Bow	2 Sep 92	10:45:29	59	49	20	9	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
626	Side	2 Sep 92	10:45:29	69	53	9	9	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
627	Bow	2 Sep 92	10:46:44	43	36	62	10	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
628	Side	2 Sep 92	10:46:44	143	143	19	19	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
629	Bow	2 Sep 92	10:48:09	63	56	11	9	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
630	Side	2 Sep 92	10:48:09	195	195	25	25	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration							Level Ice Thickness			Ice Pressure	Floe Size	
										Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice						
Event No.	Hull Panel	Date	Time	Time of Pk Pres	Time of Pk Force	Max Local Load	Max Frame Load	Speed from GPS	Avg. Ship SOA	Total	(0 - .5 ft)	(.5 - 1 ft)	(1 - 2 ft)	(2 - 4 ft)	(4 - 6 ft)	(2nd Year & Multi-Year Ice)	Avg.	Max	Snow Depth	(None, Some, Extreme)	Avg.	Max
			(GMT)	(psi)	(psi)	(LT)	(LT)	(kt)	(kt)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(ft)	(ft)	(ft)		(ft)	(ft)
631	Btm	2 Sep 92	10:49:44	147	147	51	45	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
632	Bow	2 Sep 92	10:58:18	194	194	29	29	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
633	Bow	2 Sep 92	10:59:16	120	107	26	26	Gap	2	9			1	6	2		3.5	4	1.5	N	75	200
634	Bow	2 Sep 92	11:01:06	260	260	77	64	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
635	Bow	2 Sep 92	11:03:33	141	127	87	31	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
636	Bow	2 Sep 92	11:04:35	202	102	53	31	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
637	Bow	2 Sep 92	11:05:37	33	28	12	5	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
638	Side	2 Sep 92	11:05:37	35	35	5	5	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
639	Bow	2 Sep 92	11:07:14	320	275	60	48	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
640	Side	2 Sep 92	11:08:01	33	27	5	4	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
641	Side	2 Sep 92	11:10:34	45	45	10	10	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
642	Bow	2 Sep 92	11:12:51	380	280	104	60	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
643	Bow	2 Sep 92	11:14:42	145	125	29	22	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
644	Bow	2 Sep 92	11:16:07	117	84	40	23	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
645	Bow	2 Sep 92	11:16:42	280	173	168	42	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
646	Bow	2 Sep 92	11:18:19	236	236	48	35	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
647	Btm	2 Sep 92	11:18:19	23	23	12	6	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
648	Bow	2 Sep 92	11:21:11	153	89	32	26	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
649	Bow	2 Sep 92	11:23:10	213	124	59	32	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
650	Bow	2 Sep 92	11:25:47	170	109	78	25	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
651	Side	2 Sep 92	11:25:47	35	21	5	5	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
652	Bow	2 Sep 92	11:27:59	100	99	22	15	Gap	5.5	9			2	6	1		3.5	4	1.5	N	75	200
653	Side	2 Sep 92	20:39:48	229	229	29	29	Gap	3	5				5					1.5	N	300	900
654	Bow	2 Sep 92	20:42:18	206	127	40	31	Gap	3	5				5					1.5	N	300	900
655	Side	2 Sep 92	21:09:16	46	46	7	7	Gap	4.5	5				5					2	N	300	900
656	Bow	2 Sep 92	22:13:58	177	159	28	26	Gap	3.5	8			2	6			2		1.5	N	300	900
657	Bow	2 Sep 92	22:24:42	95	69	39	14	Gap	3.5	8			2	6			2		1.5	N	300	900
658	Bow	2 Sep 92	22:28:42	43	15	19	6	Gap	3.5	8			2	6			2		1.5	N	300	900
659	Side	2 Sep 92	22:28:42	154	154	23	23	Gap	3.5	8			2	6			2		1.5	N	300	900
660	Side	2 Sep 92	22:29:57	178	152	47	30	Gap	3.5	8			2	6			2		1.5	N	300	900
661	Bow	2 Sep 92	22:35:39	176	93	51	31	Gap	3.5	8			2	6			2		1.5	N	300	900
662	Bow	2 Sep 92	22:38:05	204	120	83	31	Gap	3.5	8			2	6			2		1.5	N	300	900
663	Bow	2 Sep 92	22:49:43	120	93	23	20	Gap	3.5	8			2	6			2		1.5	N	300	900
664	Bow	2 Sep 92	22:54:55	558	342	142	83	Gap	3.5	8			2	6			2		1.5	N	300	900
665	Bow	2 Sep 92	22:58:04	198	124	62	29	Gap	3.5	8			2	6			2		1.5	N	300	900
666	Bow	2 Sep 92	23:09:48	16	7	6	2	Gap	5	9			3	5	1				1.75	N	300	900
667	Side	2 Sep 92	23:09:48	83	59	17	13	Gap	5	9			3	5	1				1.75	N	300	900
668	Bow	2 Sep 92	23:13:17	103	88	30	15	Gap	5	9			3	5	1				1.75	N	300	900
669	Bow	2 Sep 92	23:17:22	20	8	5	3	Gap	5	9			3	5	1				1.75	N	300	900
670	Side	2 Sep 92	23:17:22	61	53	8	8	Gap	5	9			3	5	1				1.75	N	300	900
671	Bow	2 Sep 92	23:24:27	45	17	11	8	Gap	5	9			3	5	1				1.75	N	300	900
672	Side	2 Sep 92	23:24:27	117	105	21	21	Gap	5	9			3	5	1				1.75	N	300	900
673	Bow	2 Sep 92	23:31:27	26	16	10	4	Gap	5	9			3	5	1				1.75	N	300	900
674	Side	2 Sep 92	23:31:27	90	87	13	12	Gap	5	9			3	5	1				1.75	N	300	900
675	Bow	2 Sep 92	23:37:00	399	308	89	59	Gap	5	9			3	5	1				1.75	N	300	900

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

				Single Subpanel Pressure		Hull Panel Load				Ice Concentration												
										Total	New and Grey Ice	Grey-White	First Yr Thin Ice	First Yr Med. Ice	First Yr Thick Ice	Old Ice	Level Ice Thickness			Ice Pressure	Floe Size	
Event No.	Hull Panel	Date	Time	Time of Pk Pres	Time of Pk Force	Max Local Load	Max Frame Load	Speed from GPS	Avg. Ship SOA	Total	(0 - .5 ft)	(.5 - 1 ft)	(1 - 2 ft)	(2 - 4 ft)	(4 - 6 ft)	(2nd Year & Multi-Year Ice)	Avg.	Max	Snow Depth	(None, Some, Extreme)	Avg.	Max
			(GMT)	(psi)	(psi)	(LT)	(LT)	(kt)	(kt)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(Tenths)	(ft)	(ft)	(ft)		(ft)	(ft)
676	Side	2 Sep 92	23:38:52	150	150	26	26	Gap	5	9			3	5	1				1.75	N	300	900
677	Bow	2 Sep 92	23:40:46	207	135	39	31	Gap	5	9			3	5	1				1.75	N	300	900
678	Bow	2 Sep 92	23:42:59	112	96	38	22	Gap	5	9			3	5	1				1.75	N	300	900
679	Side	2 Sep 92	23:47:43	150	150	19	19	Gap	5	9			3	5	1				1.75	N	300	900
680	Side	2 Sep 92	23:50:02	74	60	13	13	Gap	5	9			3	5	1				1.75	N	300	900
681	Bow	2 Sep 92	23:51:03	184	162	37	29	Gap	5	9			3	5	1				1.75	N	300	900
682	Bow	2 Sep 92	23:55:12	78	54	24	12	Gap	5	9			3	5	1				1.75	N	300	900
683	Side	2 Sep 92	23:55:12	75	75	10	10	Gap	5	9			3	5	1				1.75	N	300	900
684	Bow	2 Sep 92	23:59:07	169	143	51	25	Gap	5	9			3	5	1				1.75	N	300	900
685	Side	2 Sep 92	23:59:07	70	70	9	9	Gap	5	9			3	5	1				1.75	N	300	900
686	Bow	3 Sep 92	0:01:00	353	252	75	54	Gap	6	10		10										
687	Bow	3 Sep 92	0:03:17	132	111	64	20	Gap	6	10		10										
688	Bow	3 Sep 92	0:04:34	124	90	27	27	Gap	6	10		10										
689	Bow	3 Sep 92	0:05:24	270	270	85	40	Gap	6	10		10										
690	Bow	3 Sep 92	0:06:38	238	202	46	37	Gap	6	10		10										
691	Bow	3 Sep 92	0:08:30	81	75	20	12	Gap	6	10		10										
692	Btm	3 Sep 92	0:08:30	14	9	7	5	Gap	6	10		10										
693	Side	3 Sep 92	0:08:30	88	88	19	19	Gap	6	10		10										
694	Bow	3 Sep 92	0:10:13	183	183	49	30	Gap	6	10		10										
695	Bow	3 Sep 92	0:11:19	371	171	66	55	Gap	6	10		10										
696	Btm	3 Sep 92	0:11:19	15	15	10	4	Gap	6	10		10										
697	Bow	3 Sep 92	0:13:55	127	121	25	19	Gap	6	10		10										
698	Bow	3 Sep 92	0:14:41	260	132	106	39	Gap	6	10		10										
699	Bow	3 Sep 92	0:15:34	63	63	15	10	Gap	6	10		10										
700	Side	3 Sep 92	0:15:34	53	47	8	7	Gap	6	10		10										
701	Bow	3 Sep 92	0:17:12	151	127	44	22	Gap	6	10		10										
702	Bow	3 Sep 92	0:17:59	234	152	50	35	Gap	6	10		10										
703	Bow	3 Sep 92	0:18:47	255	122	53	38	Gap	6	10		10										
704	Bow	3 Sep 92	0:22:09	85	78	16	13	Gap	6	10		10										
705	Bow	3 Sep 92	0:22:56	388	223	74	60	Gap	6	10		10										
706	Bow	3 Sep 92	0:26:17	96	71	34	16	Gap	6	10		10										
707	Bow	3 Sep 92	0:27:30	166	158	47	35	Gap	6	10		10										
708	Side	3 Sep 92	0:29:13	72	53	11	9	Gap	6	10		10										
709	Side	3 Sep 92	0:31:18	125	125	25	25	Gap	6	10		10										
710	Trans	3 Sep 92	1:08:06	54	54	10	10	Gap	7.4													
711	Side	3 Sep 92	1:12:24	157	153	28	22	Gap	7.4													
712	Side	3 Sep 92	1:13:44	105	105	14	14	Gap	7.4													
713	Bow	3 Sep 92	1:15:12	91	83	24	20	Gap	7.4													
714	Side	3 Sep 92	1:17:50	156	156	20	20	Gap	7.4													
715	Bow	3 Sep 92	1:19:02	96	94	31	20	Gap	7.4													
716	Bow	3 Sep 92	1:19:49	164	125	48	27	Gap	7.4													
717	Bow	3 Sep 92	1:20:41	169	165	61	27	Gap	7.4													
718	Side	3 Sep 92	1:20:41	34	31	7	6	Gap	7.4													
719	Bow	3 Sep 92	1:21:17	237	162	45	35	Gap	7.4													
720	Bow	3 Sep 92	1:27:02	93	93	76	15	Gap	7.4													

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Continued)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
721	Btm	3 Sep 92	1:27:02	20	20	6	5	Gap	7.4													
722	Bow	3 Sep 92	1:29:23	139	82	45	21	Gap	7.4													
723	Bow	6 Sep 92	11:31:02	27	8	5	4	3.8														
724	Side	6 Sep 92	11:31:02	72	72	19	13	3.8														
725	Side	6 Sep 92	14:04:41	127	99	23	16	7.4														
726	Side	6 Sep 92	14:05:18	89	58	15	13	7.6														
727	Side	6 Sep 92	14:10:54	169	144	28	23	3.6														
728	Bow	6 Sep 92	14:11:47	43	9	7	6	3.7														
729	Side	6 Sep 92	14:11:47	77	77	19	13	3.7														
730	Bow	6 Sep 92	18:16:23	311	218	77	46	6.3														
731	Bow	6 Sep 92	18:57:43	107	30	23	16	7.3														
732	Bow	6 Sep 92	18:59:51	96	63	33	15	6.7														
733	Side	6 Sep 92	20:23:44	52	42	7	7	3.6														
734	Side	6 Sep 92	20:25:16	113	113	25	17	0.8														
735	Side	7 Sep 92	0:34:13	108	80	17	14	3.6														
736	Bow	7 Sep 92	0:40:42	124	110	31	18	5.3														
737	Side	7 Sep 92	0:40:42	83	79	13	11	5.3														
738	Side	7 Sep 92	0:41:48	76	68	16	14	2.5														
739	Bow	7 Sep 92	0:42:21	43	18	17	6	Gap														
740	Side	7 Sep 92	0:42:21	105	104	29	19	Gap														
741	Bow	7 Sep 92	0:43:37	122	108	43	19	Gap														
742	Side	7 Sep 92	0:43:37	246	239	44	32	Gap														
743	Bow	7 Sep 92	0:44:16	330	322	88	49	Gap														
744	Side	7 Sep 92	0:44:16	167	102	35	23	Gap														
745	Bow	7 Sep 92	0:48:33	149	149	22	22	Gap														
746	Side	7 Sep 92	0:48:33	54	44	9	7	Gap														
747	Bow	7 Sep 92	1:54:43	83	60	35	12	2.2														
748	Bow	7 Sep 92	13:43:31	99	99	30	15	5.5														
749	Bow	7 Sep 92	20:08:59	151	60	27	23	5.8														
750	Side	7 Sep 92	20:13:29	55	44	9	7	0.0														
751	Bow	8 Sep 92	14:06:05	87	87	36	13	5.1														
752	Bow	8 Sep 92	16:26:13	47	31	17	7	0.0														
753	Bow	8 Sep 92	16:33:57	66	63	50	13	6.2														
754	Trans	8 Sep 92	16:33:57	19	19	3	3	6.2														
755	Bow	8 Sep 92	16:34:40	65	47	49	11	6.7														
756	Bow	8 Sep 92	16:35:33	80	55	42	14	6.6														
757	Bow	8 Sep 92	16:36:05	106	60	42	16	6.9														
758	Side	8 Sep 92	16:36:05	128	128	23	16	6.9														
759	Bow	8 Sep 92	16:36:39	92	55	27	14	5.8														
760	Side	8 Sep 92	16:36:39	228	204	46	32	5.8														
761	Bow	8 Sep 92	16:37:10	107	44	27	16	6.0														
762	Side	8 Sep 92	16:37:10	174	139	33	22	6.0														
763	Bow	8 Sep 92	16:37:45	170	151	44	25	7.3														
764	Side	8 Sep 92	16:37:45	69	58	17	9	7.3														
765	Bow	8 Sep 92	16:38:16	92	63	22	14	—														

Table E-1. *Nathaniel B. Palmer* Ice Impact Data Correlated with Ship Speed and Ice Conditions (Concluded)

Event No.	Hull Panel	Date	Time (GMT)	Single Subpanel Pressure: Time of Pk Pres (psi)	Single Subpanel Pressure: Time of Pk Force (psi)	Hull Panel Load: Max Local Load (LT)	Hull Panel Load: Max Frame Load (LT)	Speed from GPS (kt)	Avg. Ship SOA (kt)	Ice Concentration: Total (Tenths)	Ice Concentration: New and Grey Ice (0 - .5 ft) (Tenths)	Ice Concentration: Grey-White (.5 - 1 ft) (Tenths)	Ice Concentration: First Yr Thin Ice (1 - 2 ft) (Tenths)	Ice Concentration: First Yr Med. Ice (2 - 4 ft) (Tenths)	Ice Concentration: First Yr Thick Ice (4 - 6 ft) (Tenths)	Ice Concentration: Old Ice (2nd Year & Multi-Year Ice) (Tenths)	Level Ice Thickness: Avg. (ft)	Level Ice Thickness: Max (ft)	Snow Depth (ft)	Ice Pressure (None, Some, Extreme)	Floe Size: Avg. (ft)	Floe Size: Max (ft)
766	Side	8 Sep 92	16:38:16	147	147	36	22	—														
767	Bow	8 Sep 92	16:38:49	169	162	40	27	6.4														
768	Side	8 Sep 92	16:38:49	247	207	63	37	6.4														
769	Bow	8 Sep 92	16:40:22	80	77	24	12	5.3														
770	Side	8 Sep 92	16:40:22	120	120	24	18	5.3														
771	Bow	8 Sep 92	16:40:48	91	50	31	18	7.6														
772	Side	8 Sep 92	16:40:48	98	87	25	18	7.6														
773	Side	8 Sep 92	18:40:31	217	209	39	28	1.2														
774	Bow	8 Sep 92	18:41:13	72	72	18	11	2.1														
775	Side	8 Sep 92	18:41:13	137	125	25	22	2.1														
776	Bow	8 Sep 92	18:41:54	58	45	10	9	1.8														
777	Side	8 Sep 92	18:41:54	115	104	24	17	1.8														
778	Bow	8 Sep 92	18:44:01	71	56	14	11	3.8														
779	Bow	8 Sep 92	18:44:35	55	51	15	10	2.7														
780	Side	8 Sep 92	18:44:35	125	90	25	18	2.7														
781	Bow	8 Sep 92	18:45:41	30	7	10	4	3.1														
782	Side	8 Sep 92	18:45:41	97	63	15	12	3.1														
783	Bow	8 Sep 92	18:46:19	81	57	35	12	3.8														
784	Bow	8 Sep 92	18:47:24	103	83	25	17	7.5														
785	Bow	8 Sep 92	19:24:48	63	41	17	12	5.0														
786	Side	8 Sep 92	19:24:48	71	39	12	9	5.0														
787	Bow	8 Sep 92	19:37:05	47	34	8	7	3.5														
788	Side	8 Sep 92	19:37:05	46	30	12	8	3.5														
789	Bow	8 Sep 92	19:39:05	26	19	7	4	2.1														
790	Side	8 Sep 92	19:39:05	100	97	17	14	2.1														
791	Bow	8 Sep 92	20:18:05	101	81	23	15	2.3														
792	Side	9 Sep 92	13:54:43	252	252	45	32	3.8														
793	Bow	9 Sep 92	14:15:34	80	50	34	13	5.5														
794	Bow	9 Sep 92	14:16:57	88	56	39	13	5.9														
795	Bow	9 Sep 92	14:18:19	66	65	60	10	6.8														
796	Bow	9 Sep 92	15:34:10	83	72	19	12	4.9														
			Maximum	735	715	236	136	11.7	8	10	2	10	5	10	7	10	5.0	8.0	3.5		600	1200
			Average	153	126	36.9	24.6	4.3	2	9.5	2.0	4.1	1.6	6.8	2.3	4.1	3.4	5.1	1.8		109	563

Project Technical Committee Members

The following persons were members of the committee that represented the Ship Structure Committee to the Contractor as resident subject matter experts. As such they performed technical review of the initial proposals to select the contractor, advised the contractor in cognizant matters pertaining to the contract of which the agencies were aware, and performed technical review of the work in progress and edited the final report.

Mr. Rubin Sheinberg –Chairman	U.S. Coast Guard
CDR Mark Noll	U.S. Coast Guard
Mr. Fred Seibold	Maritime Administration
Mr. Alfred Tunik	American Bureau of Shipping
Mr. Ian Bayly	Transport Canada
Mr. Alex Stavovy Dr. Robert Sielski	National Academy of Science, Marine Board Liaison
CDR Steve Sharpe	U.S. Coast Guard, Executive Director Ship Structure Committee